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X-IRRADIATION EFFECTS ON THE GENERAL BEHAVIOUR OF THE COCKROACH, *PERIPLANETA AMERICANA*

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The effects of single whole-body X-irradiation with varying doses on mortality of cockroaches were studied. The LD_{50} dose was found to be remarkably high suggesting more radioresistant nature of insects. The mortality rate, the development of radiation-induced syndromes, the degree of disorder and the recovery tendency were shown to be post-irradiation time and dose dependent.

(*Key words* : **X-irradiation, cockroach,** *Periplaneta americana*, **LD_{50} dose, mortality, radiation-induced syndromes**)

INTRODUCTION

Radiation impinges on living organisms in a variety of ways and certain types of ionizing radiation produce deleterious effects in all forms of life. These changes may be grossly apparent and may be visible soon after exposure of the organism depending on the dose range. The time-dose relationships studied by KONDRATEV (1970) in rats, SCHENKEN & HAGEMANN (1975) in mice, and IVASHIN *et al.*, (1976) in mice, SPALDING et al., (1975) in monkeys, TAHMISIAN & BETTY (1971) in grasshoppers illustrate radiation injury expressed in the form of syndrome development and mortality rate.

The present study was directed to investigate the effects of lethal and sublethal doses of X-radiation on mortality rate and the behaviour of the cockroach, *Periplaneta americana*.

MATERIAL AND METHODS

Adult male cockroaches of approximately same size and weight (1 to 1.25 g) were selected and irradiated singly from the dorsal side with required doses aerobically. The X-ray unit used for irradiation was a Philips generator Model DA 1 PW 1009/30 NR D 794. The animals were exposed at the rate of 175 R/min as described by VIJAYALAKSHMI *et al.* (1977) and the irradiation was conducted at a specific time period (10.00 AM) of the day in order to avoid circadian fluctuations in radiation sensitivity (LAPPENBUSCH, 1971). After irradiation, the cockroaches were kept in a temperature and humidity-controlled room ($27\pm2°C$, $75\pm5\%$ RH).

Determination of Lethality and LD_{50}

Adult male cockroaches were divided into nine batches of 10 animals each and each batch of animals was subjected to single whole-body irradiation with varying doses (500 to 60,000 R). The number of animals in each group that died within 5 days was tabulated. The dose with which 50% of test animals died within a specific post-irradiation period (5 days) was considered as LD_{50} of the animals. The mean death time of each group was noted. The post-irradiation effects on animal behaviour and mortality rate were observed from time to time. The same experimental observation was repeated on 3 successive days. A non-irradiated control group was included to provide an indication of the general condition of the colony. The cumulative calculation of LD_{50} was carried out by the method of BEHREN (1975).

RESULTS AND DISCUSSION

LD_{50}

The semilogarithmic graph plotted (Fig. 1) with amount of radiation on semilogarithmic scale represents a characteristic sigmoid

curve. It is evident from this curve that below a certain threshold (1000R) the animals registered no mortality. But with increasing doses from 1000 to 20,000R more deaths were recorded (Table 1) and above 25,000R, 100% mortality was observed. The LD_{50} value obtained by cumulative mortality calculation was almost identical with semilogarithmic graph value (10,560 10,250R). However, the LD_{50} values are dependent on many factors such as dose rate, type of radiation, strain of the animal, size and sex of the species and time in which the experiments are done (CASARETT, 1968). From the survey of available literature, it is known that insects are highly radio-resistant when compared to higher animals except at the earliest embryonic stages (MURAKAMI, 1965). The higher radio-resistant nature as observed in *Periplaneta* may be accounted for insects having a different pattern of cell proliferation than other organisms.

Mortality rate

The mortality rate was found to be dose dependent (Fig. 1; Table 1). The mean death time within which period the whole set of animals were found dead also differed with dose range (Fig. 2). In other words, the mean death time increased with decreasing dosage and *vice versa*. Sublethal doses produced early deaths (within 1 day) and thereafter the animals showed a sort of recovery tendency. The possibilities for this revival may be (1) intracellular recovery might be obtained by the resynthesis of destroyed or inactivated molecules and prompted by neutralization of secondary effects; (2) the radiotoxins that were released

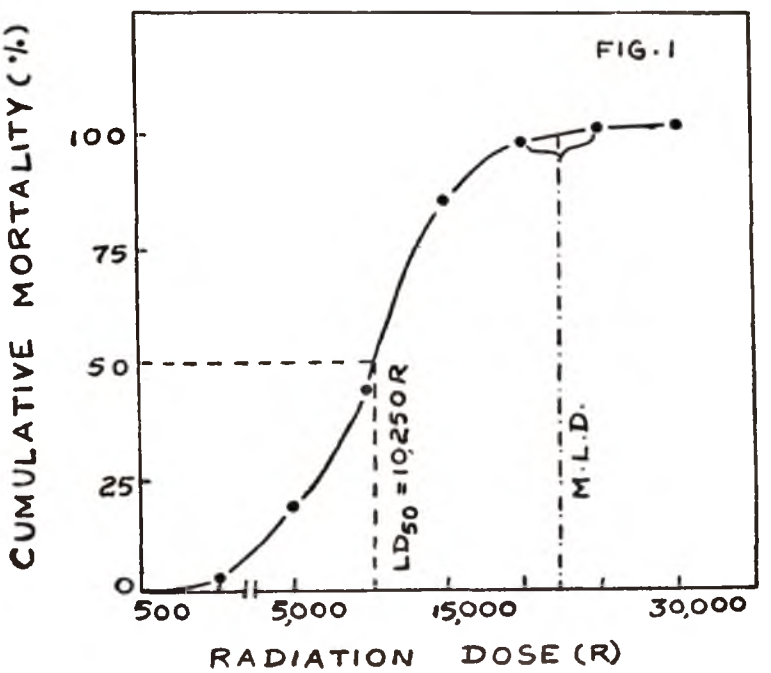

Fig. 1. Determination ef LD_{50} and MLD with varied doses ef X-irradiation in the cockroach, *Periplaneta americana*.

LD_{50} : 50 per cent lethal dose ; MLD : Minimum lethal dose

TABLE 1. LD_{50} of X-radiation for *Periplaneta americana*.

S. No.	Radiation dose (R)	Results in 5 days		Cumulative data		Per cent motality
		Lived	Died	Lived	Died	
1.	500	10	0	35	0	0
2.	1,000	9	1	25	1	4
3.	5,000	7	3	16	4	20
4.	10,000	6	4	9	8	47
5.	15,000	2	8	3	16	85
6.	20,000	1	9	1	25	97
7.	25,000	0	10	0	35	100
8.	30,000	0	10	0	45	100
9.	60,000	0	10	0	55	100

(LD_{50} = 10,560 R)

(BACQ & ALEXANDER, 1956) due to radiation dose of low intensity may be metabolised by the system. There is also evidence to suggest that damage and recovery may be influenced by the chemical interactions between radiosensitive and radioresistant organs under whole-body irradiation (SPALDING *et al.*, 1975).

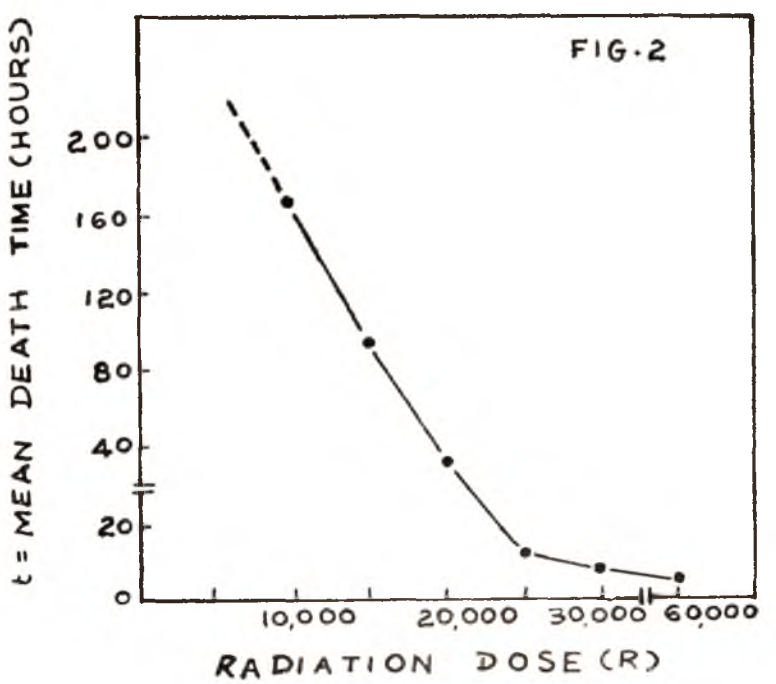

Fig. 2. Determination of mean death time under different lethal doses of X-irradiation in the cockroach, *Periplaneta americana*.

Lethal doses of 10,000 to 20,000R resulted in shortening of mean death time, while acute radiation exposure with 25,000 to 60,000R caused immediate massive deaths (10 to 2 hours after exposure). Thus LD_{50} and higher doses of X-rays produced irreversible damage to various systems and the tolerance reached beyond the limits of survival. This type of massive deaths might probably be due to sudden release of decomposition products of cells into circulating blood which are considered to be highly noxious (BACQ & ALEXANDER, 1966). EVERS (1971) reported that radiotoxins such as organic peroxides, hydrogen sulphide and ammonia were produced after whole-body irradiation. These substances may not be metabolised by the system and consequenly results in permanent chemical and molecular damage to the system which ultimately induced fatal deaths.

Radiation sickness and general behaviour

Following irradiation, a variety of syndromes were observed. Some were visible to the naked eye and others were microscopic. Sublethal dose exposure resulted in sluggish movements and inactive feeding habits indicating the symptoms of radiation sickness upto 3 days. Thereafter the animals appear to get revived to normal condition. Below 5000R no visible lesions were found and their behaviour was almost identical with the control group. At high doses (above 10,000R) the coxal leg joints became feeble and the animals were inactive in their movements. The terminal syndrome of hyperexcitability and inco-ordination followed by sluggish behaviour suggests probable damage to the central nervous system which finally leads to death. The animals also exhibited restlessness and prostration followed frequently by abdominal convulsions.

The studies of GINGRICH (1974) on induced histological and histochemical changes in the integument of newly molted cockroaches by UV-irradiation showed damage to tergosternal muscles, leg muscle attachments and hypodermal cells which finally resulted in the inhibition of melanization and tanning. Thus induced deaths by X-irradiation as observed in the present investigation may be the result of a sum of varied kinds of injuries exceeding a critical threshold. The radiation injury to subcellular structure represents its vulnerability to such high doses of genetically important nuclear material (CASARETT, 1968). The " graded response " to irradiation was thus noticed in terms of radionecrosis and mortality rate which in turn reflects its dose-dependent vulnerability in *Periplaneta*.

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STUDIES ON THE EFFECT OF TEMPERATURE ON THE DEVELOPMENT OF *OPPIA NODOSA* HAMMFR (ACARI : CRYPTOSTIGMATA : OPPIIDAE)

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Oppia nodosa HAMMFR, **reproduces parthenogenetically in laboratory cultures. The duration of development from egg to adult depends on the prevailing temperature. At 8°C, there is no reproduction. In the uncontrolled room temperature development from egg to adult occurs in 16 days. At 16°C, 24°C and at 32°C the duration of development is 54 days, 21 days and 14 days respectively. Variations in size of the body and the structure of sensillus during different developmental stages has been shown. In laboratory cultures the mite feeds upon *Cunninghamella* sp. and *Rhizopus* sp. but rejected *Penicillium* sp. This species of oribatid mite is recorded here for the first time from India.**

(*Key words* : **Oribatid mite, *Oppia nodosa*, reproduction, effect of temperature**)

INTRODUCTION

Little is known regarding the factors affecting the duration of development in oribatid mites. According to LEBRUN (1964) litter dwelling forms develop at a faster rate than the humus dwellers. He further holds that primitive oribatids take longer time to develop than the higher ones and for species in the same superfamily the life cycle is proportional to the size of the mite (LEBRUN, 1970). Within the same species, however, duration of development varies under different environmental conditions (WALLWORK, 1970). The present investigation involves experimental studies in controlled laboratory conditions to find out the role played by temperature on the hatching and development of *Oppia nodosa* HAMMER, which occurs in the soil of Santiniketan (23°39'N, 87°42'E; 58·9 m elevation) throughout the year. This species is recorded here for the first time in India.

METERIALS AND METHODS

Freshly emerged adults of *Oppia nodosa* from the laboratory stock cultures were used in the present experiment. The stock cultures were raised from specimens collected alive in large numbers from the litter layer. The rearing cells, having 3.5 cm diameter and 4 cm height, made of plastic, were filled with sterilized fine earth upto 1.5 cm height. Water was regularly added in all the cells to maintain sufficient moisture. Powdered yeast was supplied as food in small amounts once a week. During each set of experiment 10 specimens were taken in a rearing cell and 6 such rearing cells each were placed in four different constant temperatures *viz.*, 8°C, 16°C, 24°C and 32°C with relative humidity varying between 80–90% and at uncontrolled laboratory condition where temperature and relative humidity fluctuated within the range of 16–34°C and 63–100% respectively.

OBSERVATIONS

Oppia nodosa reproduced parthenogenetically in laboratory cultures. These bred successfully at different temperature con-

ditions except for 8°C where individuals remained in a dormant state. Although 10 days onwards at 8°C some individuals started showing signs of life yet there was no egg laying till 60 days, after which these were transferred back to the uncontrolled laboratory condition, where they oviposited. These eggs developed into adults in about 16–18 days. The adult females started laying eggs in about 2 days time at 24°C and 32°C, while they took 4days at room temperature and 7 days at 16°C. The eggs were semi-opaque somewhat reniform in shape (Figs. 1 & 2) and without any ornamentation on the surface. Usually the eggs were laid singly on the yeast, fungus mycelia or in small cracks and crevices in the culture media. Sometimes a group of upto fifteen eggs were also noticed. At 24°C, the 60 female adults laid a total number of 243 eggs in only 5 days suggesting an average rate of one egg per female per day. The egg production ceased after about 26 days except at 16°C where oviposition continued till the end of the experiment (Fig. 11). In overcrowded colony there was no egg laying either by old or freshly emerged female. However, when these individuals were transferred to new rearing cells oviposition soon took place.

The incubation period varied depending upon the temperature. At 16°C it was 7 days, at 24°C 3 days, and at 32°C and in room temperature it was 2 days. Hatching took place by splitting of the egg membrane along the lateral sides. There is no prelarva and the larva on emergence soon started feeding.

The larval period varied from 2 to 3 days except at 16°C where it was extended upto 7 days (Table 1). The larva (Fig. 3) increased considerably in size by the time it entered a brief quiescent premoult stage from which the protonymph emerged out. Protonymphal stage (Fig. 4) lasted for 7 days at 16°C, 5 days at 24°C and 2 days at 32°C and in room temperature. The deutonymphal stage (Fig.5) was somewhat longer being 4 days at 32°C and in room temperature and 6 and 8 days at 24°C and 16°C respectively. The tritonymphs (Fig. 6) were bigger and quite agile with legs and mouthparts conspicuously sclerotized. They actively fed upon the yeast and fungi, before undergoing a quiescent stage which often extended upto 2 days. The tritonymphal stage in the present experiment lasted for 4 to 5 days except at 16°C where it was longer enough to take 15 days. The newly emerged adults (Fig. 7) were weakly sclerotized and pale brown in colour. The colour changed to dark brown in about 2 days. However, the fresh adult progeny could easily be distinguished from the older ones by its glistening body colour upto quite a few days. The total duration of development from egg to adult was thus 54 days at 16°C, 21 days at 24°C, 14 days at 32°C, and 16 days in the uncontrolled room temperature (Table 1).

The exuvium in all instars split along the postero-lateral margin and the emerging individuals retreated out from the old exoskeleton (Fig. 8). Sometimes the newly emerged instars consumed their castout exuvia. This behaviour was particularly common in newly emerged adults which often devoured the entire posterior portion of the hysterosoma. Among the three major fungi growing upon the yeast in the culture media the adults and juveniles of the *Oppia nodosa* consumed *Cunninghamella* sp. and *Rhizopus* sp. but not the *Penicillium* sp.

Average length and breadth of each developmental stage, soon after their emergence, are shown in Table 2. The most remarkable morphological change from larva to adult is that of the sensillus which changed

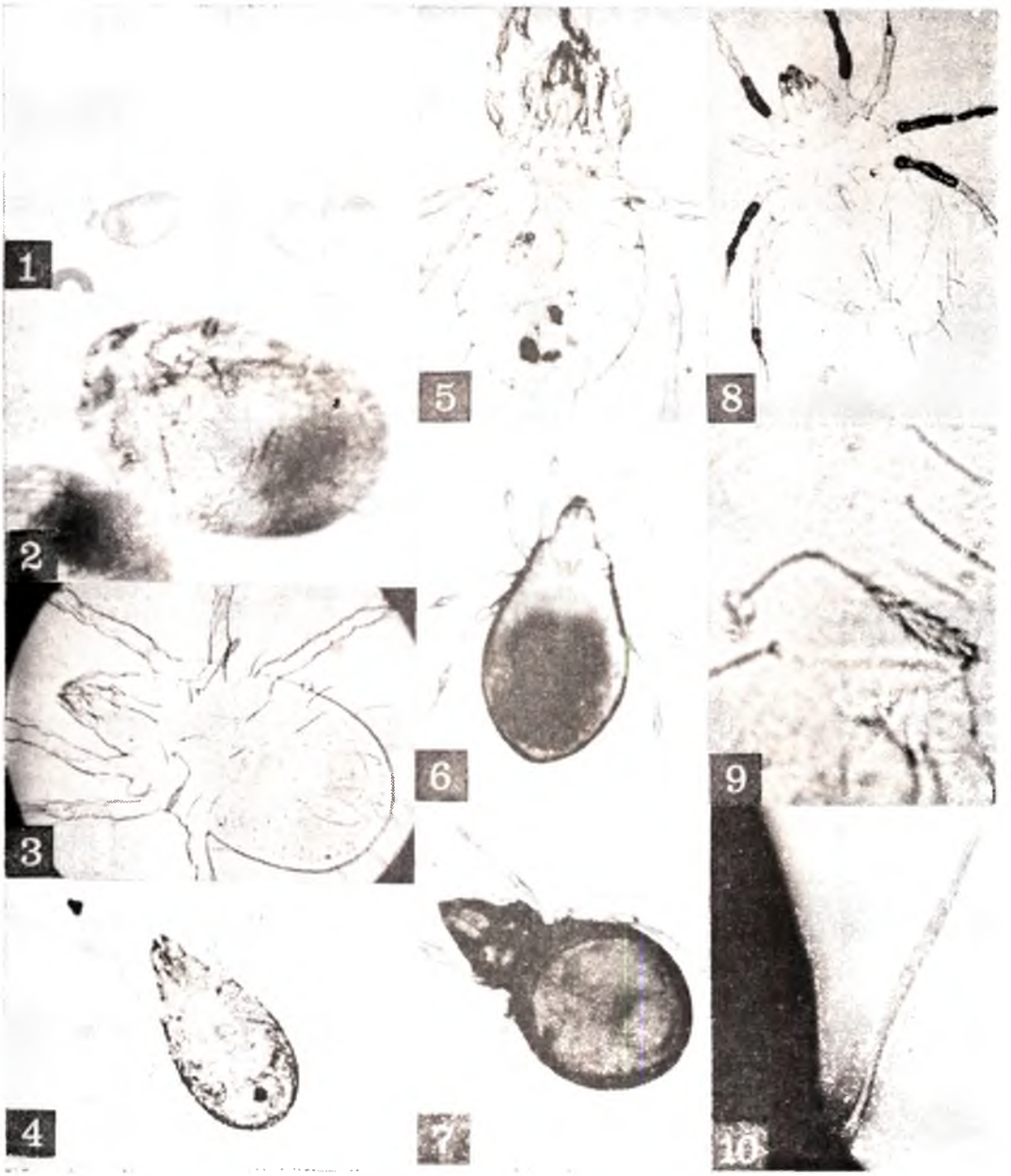

Fig. 1. Freshly laid eggs of *Ogula nobsa*; Fig. 2. Egg just before hatching showing larval legs; Fig. 3. Hexapod larva; Fig. 4. Protonymph; Fig. 5. Deutonymph; Fig. 6. Tritonymph; Fig. 7. Adult; Fig. 8. Cast-off exuvium of the tritonymph showing postero-lateral splitting of exoskeleton; Fig. 9. Sensillus of larva; Fig. 10. Sensillus of adult.

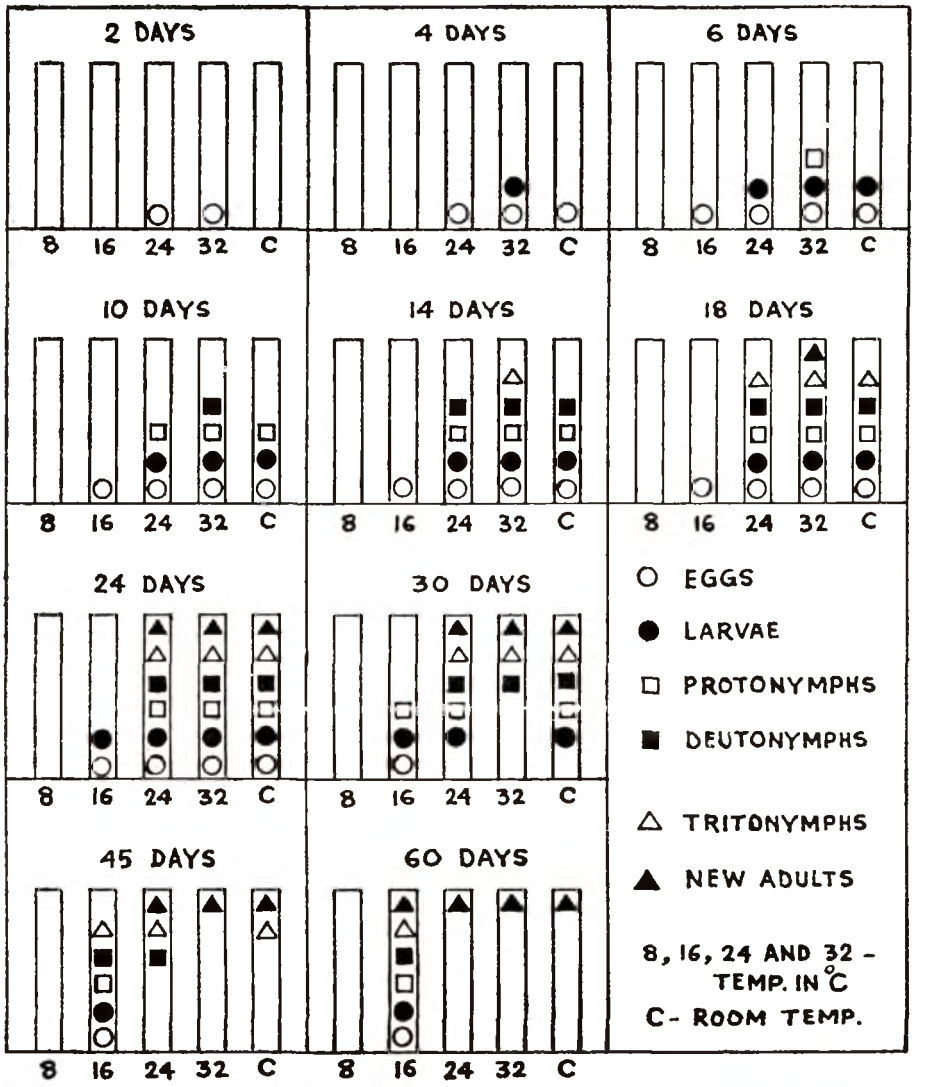

Fig. 11. Occurrence of different developmental stages in the rearing cells in relation to temperature at different time intervals.

TABLE 1. Duration of development in days at different temperature.

Developmental stages	8°C 87%RH	16°C 89%RH	24°C 87%RH	32°C 81%RH	Room temp: 16°C-34°C; 63-100%RH
Incubation period	–	17	3	2	2
Larva-Protonymph	–	7	2	2	3
Protonymph – Deutonymph	–	7	5	2	2
Deutonymph – Tritonymph	–	8	6	4	4
Tritonymph – Adult	–	15	5	4	5
Egg – Adult	–	54	21	14	16

from a spindle shaped spiculate head on a shaft (Fig. 9) to a sparsely barbed lanceolate structure (Fig. 10).

TABLE : 2. Total length and breadth of the developmental stages of *Oppia nodosa*.

Stages	Total length (μ) $x \pm$ S D	Total breadth (μ) $x \pm$ S D
Egg	130 ± 6.7	96 ± 5.1
Larva	195 ± 8.0	107 ± 6.0
Protonymph	245 ± 18.0	128 ± 11.3
Deutonymph	341 ± 21.3	176 ± 12.3
Tritonymph	477 ± 9.8	251 ± 10.7
Adult	523 ± 23.77	275 ± 14.49

DISCUSSION

Like many other cryptostigmatid mites, *Oppia nodosa* also reproduces parthenogenetically. As in *Oppia nov* (WOODRING & COOK, 1962), it seems, only one egg matures at a time and the oviposition occurs continuously throughout the reproductive period. A temporary cessation in oviposition may however occur due to overcrowding in a limited space. As in the present investigation LUXTON (1972) and MITCHELL & PARKINSON (1976) found that the oribatid mites have low preference for *Penicillium* sp. as food. On the other hand HARTENSTEIN (1962) found that *Penicillium* sp. acted as a repellent during feeding for *Ceratozetes gracilis*.

The temperature has been considered as one of the most important limiting factors in tropical conditions. CHAUDHURI & BHATTACHARYYA (1975) have stressed the importance of temperature in hatching success and duration of development in a collembolan species *Lobella* (*Lobella*) *maxillaris* which widely inhabits soils of tropical India. Duration of development in *Oppia nodosa* varies with the prevailing temperature. At 24°C, it develops in about the same time as in *O. nova* which requires 23 days at 25°C (WOODRING & COOK, 1962.) However compared to *O. nitens* it develops at a faster rate. MICHAEL (1883) reports a 40 days development time for the same at 25°C.

The duration of development obtained under controlled experimental conditions probably give shorter developmental time compared to that in field. Yet MITCHELL (1977) found for *Ceratozetes kananaskis* a good correspondance between the field and laboratory data. LEBRUN (1964), in his studies on the Cryptostigmata of a Belgian forest floor has suggested two generation per year for *O. nova* and 3 to 5 for *O. quadricarinata* and *O. subpectinata*. It seems in Santiniketan, *O. nodosa* has many more generations compared to the oppioid species of temperae regions.

Acknowledgement:- The authors remain thankful to Prof. A. B. Das, Head, Department of Zoology for providing facilities and to Dr. S C. Pal, Department of Botany for his help in identifying the fungi. Thanks are also due to the Council of Scientific and Industrial Research, New Delhi for awarding fellowships to VCJ and SJ.

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INCIDENCE OF MORPHOLOGICAL MUTANTS IN *CHRYSOMYIA MEGACEPHALA* (CALLIPHORIDAE : DIPTERA) UNDER THE INFLUENCE OF LUNAR AND SOLAR ECLIPSES

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(Received 14 October 1977)

The wild flies of *Chrysomyia megacephala* (Calliphoridae : Diptera), when reared in the laboratory produced 2–16 % of adults having abnormal characteristics like the runts, curled wings and vestigial wings etc. However, the normal forms of its larvae and pupae, when exposed to the rays of the lunar and solar eclipses that occurred on the 19th Nov. 1975, 29th April 1976 and 23rd Oct. 1976 respectively resulted not only in a large number of naturally occurring mutants but also some flies with new characteristics viz., wingless, one wing missing, defective wings, abdomen with a peacock- or jet black colour and with vestigial wings and runts. The larvae under experimental conditions had a delayed pupation and also showed a higher percentage of mortality.

(Key words : Chrysomyia megacephala, **Calliphorid, morphological mutants, lunar eclipse, solar eclipse)**

INTRODUCTION

Occurrence of individuals with morphological diversities have quite frequently been reported in the dipteran flies (MILANI, 1967; SHARMA *et al.*, 1976), but such reports about the forms belonging to the family Calliphoridae are unknown. The present paper, therefore, deals with the morphological mutants of *Chrysomyia megacephala* obtained not only from the laboratory cultures but also on exposure to the rays during the time of lunar & solar eclipses.

MATERIALS AND METHODS

The rearing of the fly, *Chyrsomyia megacephala* was done as described earlier (KAUR, 1971). The number of larvae and pupae, obtained from the laboratory culture and exposed to the rays of the moon and sun during the respective eclipses in the months of November, 1975 ; April, 1976 and October, 1976 are recorded in Tables 2, 3 and 4. The frequency of the available mutant forms in these cultures was also studied. The control larvae and pupae were kept away from the rays of the eclipsed bodies in a closed room.

RESULTS

Spontaneous occurrence of morphological mutants in the laboratory cultures

The various larvae and pupae of the cultures 1–4 maintained in the control experiments resulted in the emergence of abnormal flies to the tune of 2,2,3,1 respectively (Table 1.) The mutant flies have such characters as vestigial wings (VW), runt (rt) and curled wings.

Occurrence of morphological mutants after lunar eclipse

The flies after this exposure of about 30 minutes on 19th Nov., 1975 revealed a higher percentage of mutant forms which are normally met with in its laboratory cultures (Table 2). In addition, a few new types of mutants with characteristics like wingless, defective wings (df) and one wing missing, also appeared.

TABLE 1. Frequency distribution of normal and abnormal flies in the laboratory cultures.

Culture No.	Total number of Larvae (L) / Pupae (P)	Total flies hatched	percentage of hatchability	Number of normal flies hatched	Number of abnormal flies hatched	Mortality (Lethals)	Type of abnormality
1.	15 (P)	13	86.67	11(84.61%)	2(15.39%)	2(13.33%)	VW (1♂) ; runt (1♂)
2.	15 (L)	12	80.00	10(83.33%)	2(16.67%)	3(20%)	runt (1♂) ; curled (1♀)
3.	60 (P)	51	85.00	48(94.12%)	3(5.88%)	9(15%)	VW(2♂); curled (1♂)
4.	40 (L)	36	90.00	35(97.22%)	1(2.78%)	4(10%)	curled (1♂)

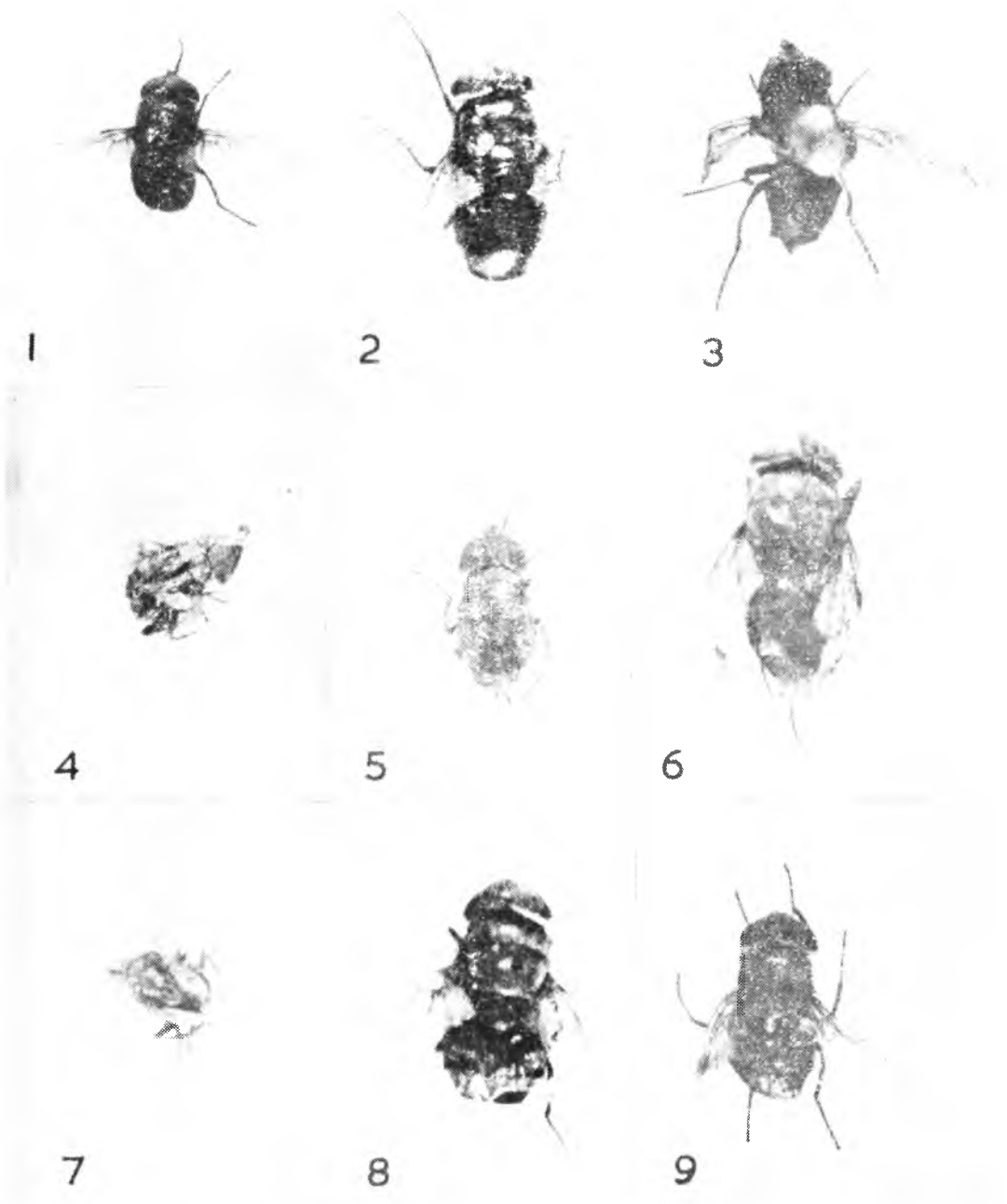
Occurrence of morphological mutants after solar eclipse

The larvae and pupae of the fly were also exposed to the rays of the sun during the solar eclipse for a duration of half an hour on the 29th April, 1976 and one hour on 23rd Oct., 1976 (Tables 3 & 4). Surprisingly the flies still revealed an increase in the percentage of the already available types of mutant forms. In addition, the flies with variable abdominal colour i.e., peacock colour to jet black also appeared. The larvae had delayed pupation and the percentage of mortality also increased. Some of the individuals that emerged had a combination of two abnormalities i. e., vestigial wings and runt (VW & rt).

DISCUSSION

The changes in the morphological characteristics within an individual by the action of X– or gamma–rays or by chemical mutagens and also the random occurrence of such mutant forms both in the field population and in the laboratory cultures have quite frequently been reported and these have been reviewed by MILANI (1967).

In *Chrysomyia megacephala*, eight morphological deformities have been observed. These arose spontaneously in the laboratory cultures and also when exposed to the rays of the moon or the sun during the lunar and solar eclipses. The abnormalities produced appear to be due to the effect of cosmic rays, the intensity of which is known to increase several times during eclipses on account of the effects of diffraction and the changes in the distribution of wave length of the radiations. The results, of course, are not as evident as in the case of selected wave lengths i.e., of X-rays and γ-rays which are now extensively used for sterlization of insects for their control. The



Figs : 1. N ♂ – Normal male ; 2. N ♀ Normal female ; 3 & 6. df - defective wing mutant ; 4. rt – runt mutant ; 5. Vw – Vestigial wing mutant ; 7. rt and Vw – runt and Vestigial wing mutant ; 8. curled (cu) – Curled wings mutant ; 9 – One wing Vw – One wing vestigial

TABLE 2. Frequency distribution of normal and abnormal flies after the lunar eclipse of the 19th November, 1975.

Date of emergence of flies	Material exposed Larvae (L)/ Pupae (P)	Total flies hatched	percentage of hatchability	Number of normal flies hatched	Number of abnormal flies hatched	Mortality (Lethals)	Type of abnormality
23rd Nov., 1975	258 (P)	93	36.05	64(68.82%)	29(31.18%)	9(3.49%)	Wingless (1♂); df (8♂; 4♀); runt (1♂ 1♀); VW(8♂, 5♀); one wing (1♂).
25th Nov., 1975		60	23.30	42(70.00%)	18(30.00%)	12(4.67%)	Curled (6♂, 4♀); Wingless (1♂); VW(4♂, 3♀).
26th Nov., 1975		27	10.47	20(74.08%)	7(25.92%)	4(1.55%)	Curled (1♂, 2♀); VW (2♂, 1♀); runt (1♂).
27th Nov., 1975		33	12.79	22(66.67%)	11(33.33%)	20(7.75%)	Curled (3♂, 2♀); VW(2♂· 3♀); runt (1♂).
28th Nov., 1975	251(L)	25	9.97	16(64.00%)	9(36.00%)	10(3.98%)	df (2♂, 1♀); Wingless (1♀); curled (2♀); VW(2♂, 1♀).
29th Nov., 1975		58	23.40	42(72.42%)	16(27.58%)	20(7.97%)	runt (1♀); df (3♂, 2♀); curled (1♂, 2♀); VW(5♂, 2♀).
30th Nov., 1975		42	16.73	30(71.43%)	12(28.57%)	15(5.97%)	df (3♂, 2♀); one wing (1♂); runt (1♀); curled 2♂, 3♀).
1st Dec., 1975		44	17.53	30(68.18%)	14(31.82%)	24(9.56%)	VW(6♂, 2♀); curled (3♂, 2♀); runt (1♂).
2nd Dec., 1975		10	3.99	6(60.00%)	4(40.00%)	3(1.19%)	Curled (2♀); df (1♀); VW (1♂).

TABLE 3. Frequency distribution of normal and abnormal flies after the solar eclipse of 29th April, 1976.

Total number of Larvae (L) / Pupae (P)	Total flies hatched	Percentage of hatch-ability	Number of normal flies hatched	Number of abnormal flies hatched	Mortaiity (Lethals)	Type of abnormality
42(P)	23	54.76	10(43.48%)	13(56.52%)	19(45.24%)	VW (3♂, 1♀); runt (2♂, 2♀); curled (2♂); one wing (1♀); runt & VW (2♂).
30(L)	12	40.00	5(41.67%)	7(58.33%)	18(60.00%)	Variation in abdominal colour (1♂); runt and VW(2♂, 1♀); VW (2♀; curled (1♂).

TABLE 4. Frequency distribution of normal and abnormal flies after the solar eclipse of 23rd October, 1976.

Material exposed Larvae(L) / Pupae(P)	Total flies hatched	Percentage of hatch-ability	Number of normal flies hatched	Number of abnor-mal flies hatched	Mortality (Lethals)		Type of abnormality
					Larvae	Pupae	
19(P)	16	84.31	7(43.75%)	9(56.25%)	—	3(15.79%)	runt (2♂, 3♀); VW (1♂, 1♀); one wing VW (2♂).
2nd instar larvae(L) 193	133	68.91	70(52.63%)	63(47.37%)	20 (10.36%)	40(20.73%)	runt (23 ♂, 12 ♀); VW(5 ♂); curled wings (6♂, 8♀); df (2♂); wingless (4♂, 3♀).

availability of the mutant forms in all insect of the present type under the influence of special rays received during the lunar & solar eclipses has been studied for the first time and has revealed interesting results as presented in this paper.

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ENDOCRINE INFLUENCES ON SPERMATOGENESIS IN THE RED COTTON BUG, *DYSDERCUS CINGULATUS* (PYRRHOCORIDAE : HETEROPTERA)

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Testes in *Dysdercus cingulatus* consists of six lobes. In the early fourth instar, differentiation proceeds only upto spermatocyte stage. By the time the animal moults into fifth instar, spermatids and sperms also appear in the testis. Subsequently the sperms get loosely arranged at the basal region. When early fourth instar testis is implanted into newly moulted adult male or female, spermatids and sperms develop. However, if they are implanted into allatectomised female this differentiation does not take place, but will proceed if they are reimplanted subsequently into normal female with corpus allatum. Topical application of fernesyl methyl ether to fourth instar nymphs also facilitates testis development. However, ecdysone, either injected into nymphs or into adults carrying fourth instar testis implants, did not affect testis development. It appears that juvenile hormone stimulates transformation of spermatocytes into spermatids and sperms, but ecdysone apparently does not have any effect on this process. The influence of corpus allatum hormone appears to be direct and not mediated through nutrition.

(*Key words : Dysdercus cingulatus*, **endocrine control, spermatogenesis, farnesyl methyl ether, ecdysterone, in vivo studies).**

INTRODUCTION

The endocrine mechanisms controlling various aspects of spermatogenesis in Lepidoptera are becoming clear. They implicate a significant role for ecdysone in stimulating spermatogenesis in this group of insects (WILLIAMS & KAMBYSELLIS, 1969; TAKEUCHI, 1969; YAGI et al., 1969; KAMBYSELLIS & WILLIAMS, 1971 a; NOWOCK, 1971, 1972, 1973; TAKEDA, 1972). Studies on other group of insects, especially on Hemiptera, are on the other hand scanty and less clear-cut. Among these are those of DUMSER & DAVEY (1974, 1975 a, b) on the haematophagous insect *Rohdnius prolixus* which are the most comprehensive. While all these suggest an active involvement of ecdysone in testis development and differentiation, they appear to rule out any positive role for juvenile hormone, or even suggest a role antagonistic to that of ecdysone, abolishing the ecdysone induced enhancement in the mitotic index (DUMSER & DAVEY, 1975 b). However, the studies on *Oncopeltus fasciatus* appear to be rather inconclusive regarding hormonal influences on testis differentiation, though they also suggest a JH independent mechanism. Thus the endocrine mechanism in testis differentiation in plant bugs remains rather obscure. So a detailed study of testis differentiation in the red cotton bug *Dysdercus cingulatus* was undertaken to elucidate the probable mechanism involved in the hormonal control of differentiation of testis in this animal. The studies revealed a positive stimulatory role for juvenile hormone in testis differentiation in this animal.

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MATERIALS AND METHODS

Animals used for the present study include newly emerged 4th and 5th instar nymphs as well as adults of *Dysdercus cingulatus* reared in the laboratory on soaked cotton seeds as described by JALAJA & PRABHU (1976 a). Adults were isolated on emergence and thus animals of known age were available for study.

Hormone treatment :

Farnesyl methyl ether (FME) and Law-Williams mixture (LWM) were purchased from Eco-Control Inc., Cambridge, Mass., U. S. A. For topical application, FME and LWM were dissolved in acetone and cyclohexane respectively in such a way that 1μl of the solution contained 1μg of JH analogue. For injection, FME was dissolved in olive oil at 1μg/μl. Early 4th and 5th instar nymphs were used for topical application. FME was applied without anaesthesia on the abdomen dorsally in a single dose of either 1μg, 2μg or 5μg per animal whereas LWM was similarly applied 1μg per animal. Acetone or cyclohexane as the case may be, was applied to controls. FME was injected into early 4th and 5th instar male nymphs in a single dose of 1μg per animal; controls received an equal volume of olive oil. When the animals moulted, testes were dissected out and processed.

Ecdysone was a gift from Dr. WILLIAM E. ROBBINS USDA, ARS, Belltswille. Md., USA. It was dissolved in 10% methanol at 1μg/μl. Early 4th instar male nymphs were injected with ecdysterone either in a single dose of 1μg per animal or two injections (1μg on 1st day and 1μg on 3rd day after 1st injection.

Early 4th instar testes were implanted into newly emerged adult females, and on the same day a single dose of 1μg of ecoysterone was injected into operated animals. Another injection of 1μg was given to them on 3rd day. Controls were injected 10% methanol. Ten days after the 1st injection the animals were sacrificed and testes were processed.

For all hormone treatments, a Hamilton microliter syringe was used.

Allatectomy and implantation :

Early 4th instar and 5th instar males served as donors. Adult males and females just after emergence were the hosts. Testes were dissected out from the donor insects and kept in insect Ringer. One of the pair was implanted into the host through a small slit on the abdominal tergite. The other testis was fixed for histological study. At the termination of the experiment, the host was sacrificed and the implanted testis was dissected out and processed.

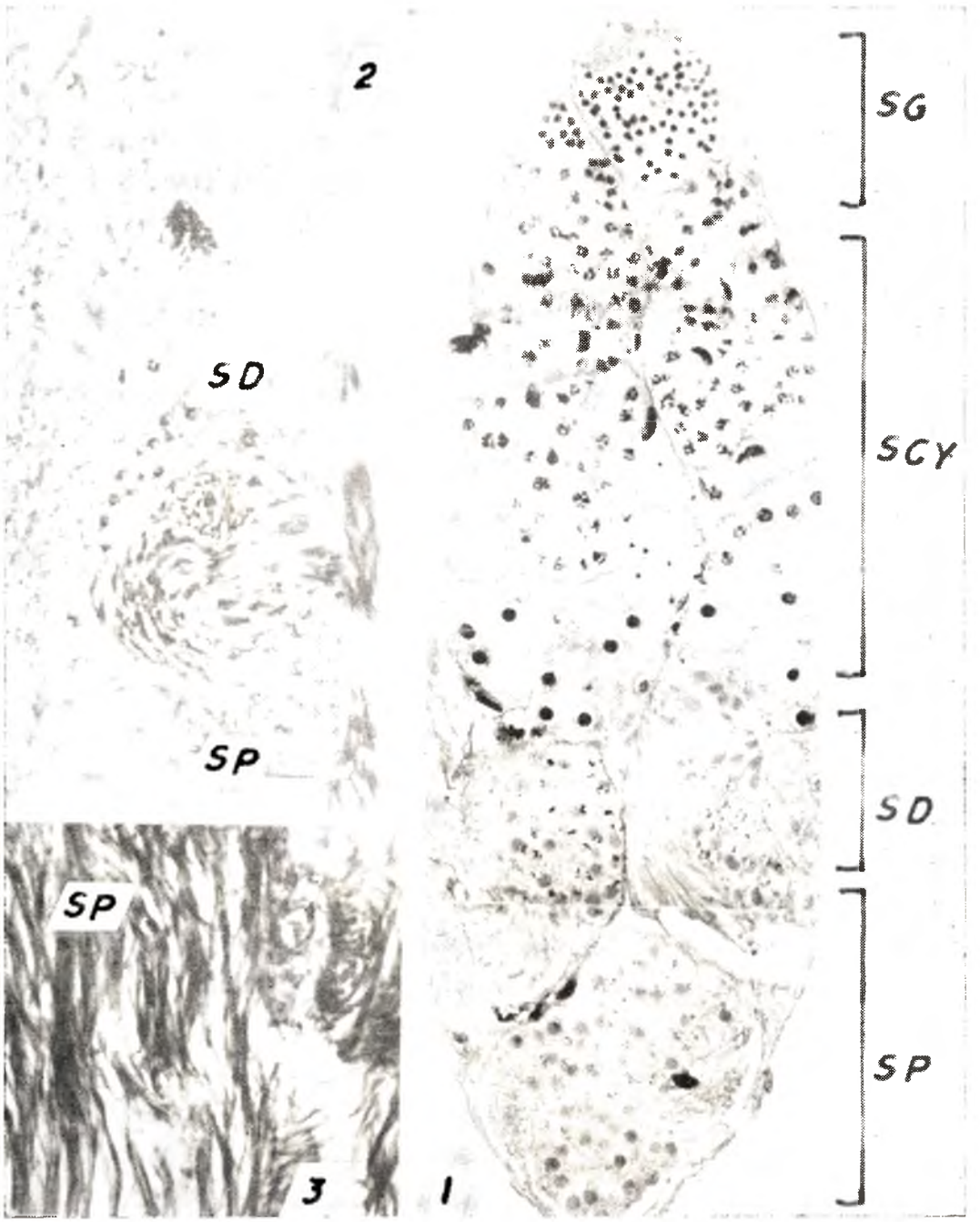
The following implantation experiments were performed: (1) Early 4th/5th instar testes were implanted into newly moulted adult male and female; similar testes implanted into other early 4th/5th instar male nymphs served as their correspanding controls. (2) Fourth instar testes were implanted into adult females allatectomised on the previous day ; testes implanted into sham operated females served as controls. The implants were recovered 5 days afterwards. (3) The experiment number 2 above was repeated ; the implants were recovered ; they were again implanted into fresh allatectomised or sham operated female as the case may be, for four days at the end of which the recovered testes were processed. (4) Experiment number 3 was repeated and the testes recovered were implanted for a third time, now into a newly emerged normal adult female for five days at the end of which the implants were processed.

Allatectomy was performed as described by JALAJA & PRABHU (1976 b). The surface at the site of all operations was made sterile by rubbing with cotton swab dipped in absolute alcohol; all the instruments used for the operation were well washed and immersed in boiling distilled water for 20–25 min and rinsed in 70% alcohol before each operation. After the operations blood was wiped off the wound with filter paper; a pinch of phenyl thiourea was placed on the wound to prevent tanning. Antibiotics or sealing of the wound was found to be unnecessary. All measurements were taken using a calibrated ocular micrometer. Measurements of testes were taken on fresh tissues.

Testes were fixed in Bouin's fluid for 4–12 hrs; tissue was processed, paraffin sections were cut and stained in Heidenhain's haematoxylin eosin in the routine manner and mounted in DPX.

RESULTS

Histological structure of the testis of *Dysdercus cingulatus* is essentially as described by BONHAG & WICK (1953) and by ECONOMOPOULOS & GORDON (1971) in *Oncopeltus fasciatus*. However, in *Dysdercus cingulatus* it consists of only six follicles instead of seven. In *Dysdercus cingulatus*,



Sections of the testis of : Fig. 1. Normal early fifth instar showing germinal zones, × 120 : Fig. 2. Normal fifth instar shwoing basal region, × 500 : Fig. 3. Normal newly moulted adult showing basal region, × 500.

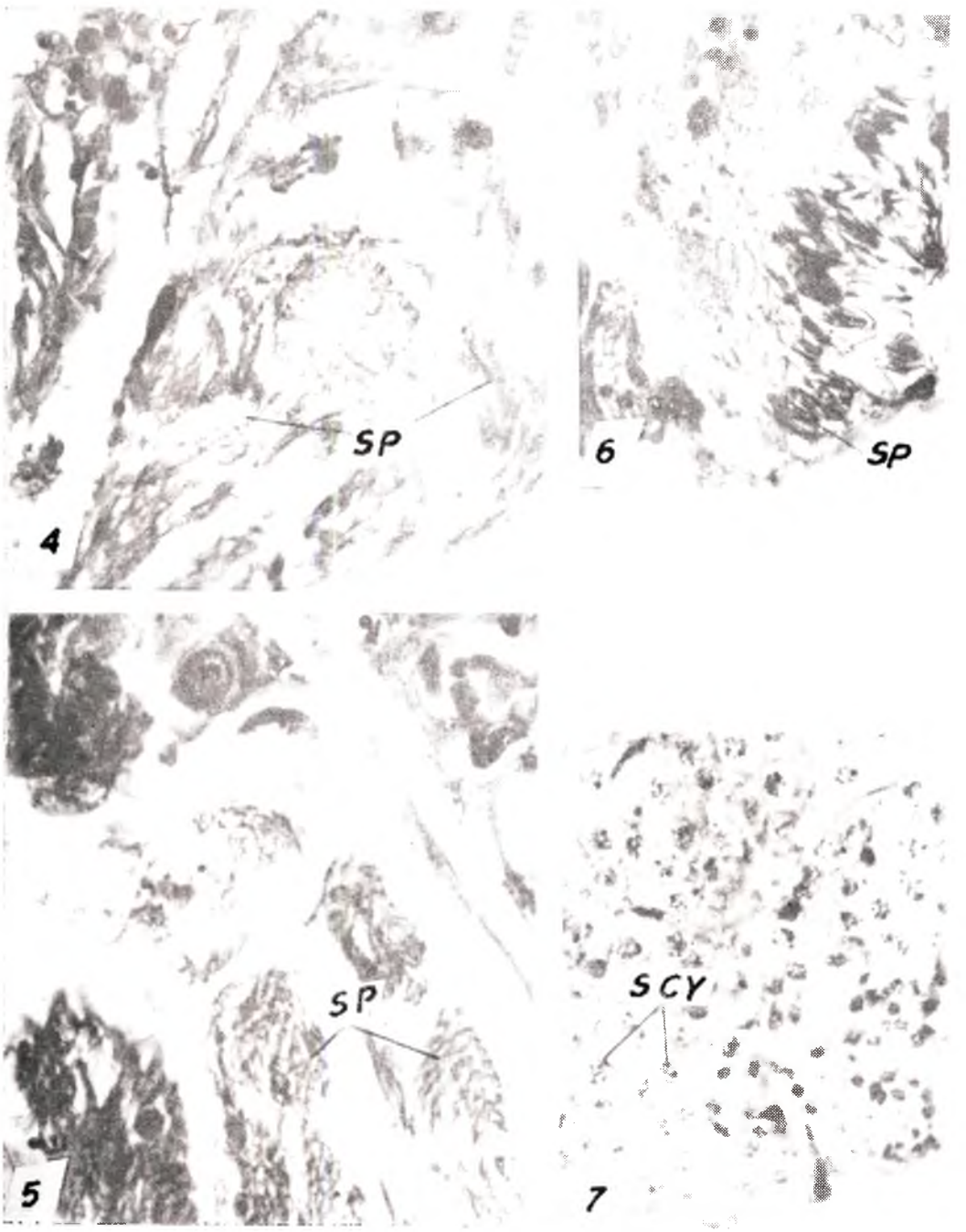


Fig. 4. Implanted fourth instar after remaining for 11 days in normal adult male showing sperms and empty spaces, ×500 ; Fig. 5. Fourth instar 11 days after implantation into normal adult male, showing sperms and empty spaces, × 500 ; Fig. 6. Fourth instar 11 days after implantation into 4th instar male nymph showing sperms and spaces, ×300; Fig. 7. Fourth instar, basal region, 10 days after two consecutive implantations in the allatectomized adult female, ×300.

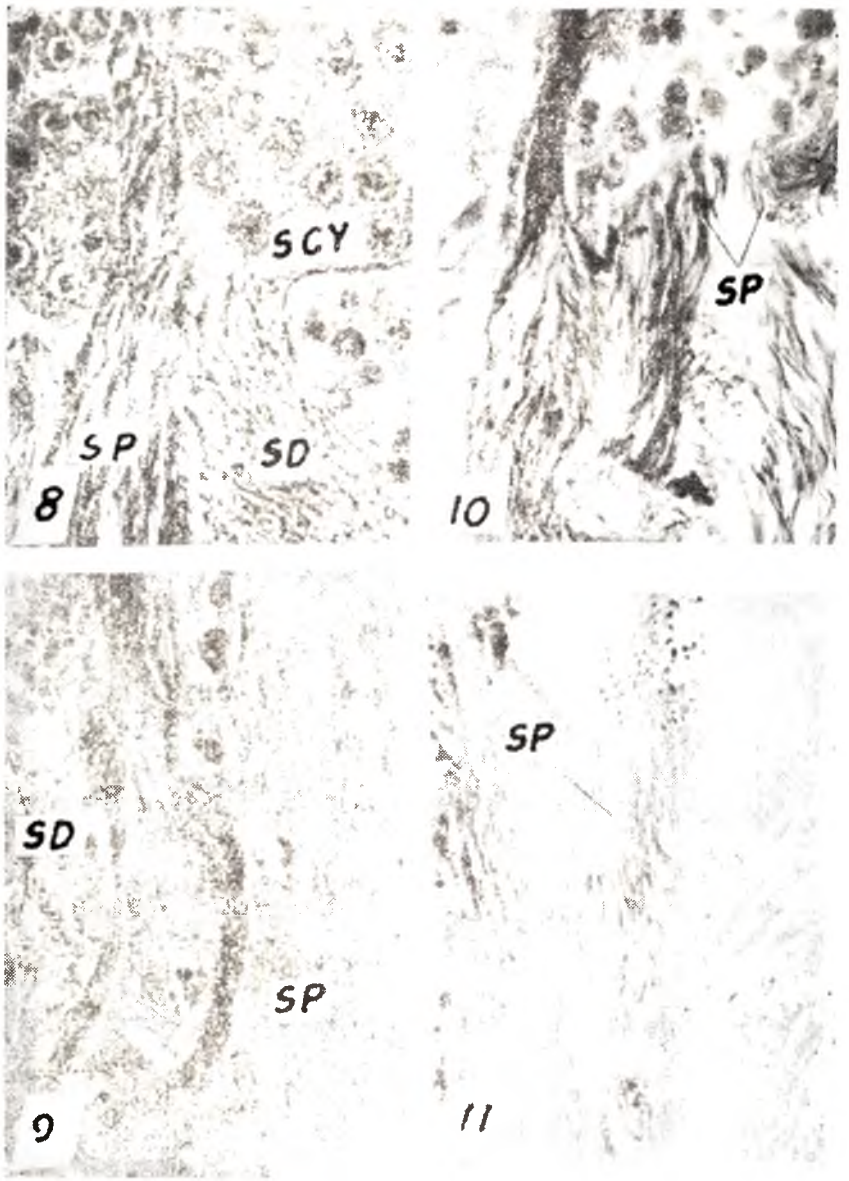


Fig. 8. Fourth instar, 10 days after two consecutive implantations in sham-operated hosts; shows well developed sperms. × 300 ; Fig. 9. Fourth instar after implantation twice consecutively for five days each, into allatectomized female and 5 days after subsequent implantation into normal newly moulted female ; shows sperms. × 300 ; Fig. 10. Sixth instar supernumerary nymph resulting from topical application of 2*µ*g farnesyl methyl ether on 4th instar. × 300; Fig. 11. Adult resulting from topical application of acetone on 4th instar nymphs ; sperms compactly packed ; × 300.

ABBREVIATIONS USED

SD spermatids ; SCY spermatocytes ; SG spermatogonia ; SP sperms. Terms in Fig. 1 show the respective zones.

TABLE 1. Mean length of the four zones of the testis follicles during various developmental stages

(Measurements are in μ).

Stage	germarium	zone of spermatocytes	Zone of maturation & reduction	Zone of transformation
Early 4th instar	6	700	190	44
Late 4th instar	6	158	485	299
Early 5th instar	6	150	237	607
Late 5th instar	6	148	86	1110
Newly moulted adult	6	140	80	1288

in the early 4th instar, differentiation proceeds only upto spermatocyte stage; spermatids appear in the late fourth instar; sperms are already present in the early 5th instar (AMBIKA, 1973). Thus by the time the animal moults into 5th instar, the testis contains germ cells at all stages of differentiation (Fig. 1). Subsequently the sperms further elongate and get themselves loosely arranged at the basal region (Fig. 2). At adult emergence, there are fewer spermatogonia and spermatocytes, most of the space in the tesis being filled with sperms (Fig. 3). The testes are larger now, attaining $1500 \times 650\mu$. Mean length of various zones in the testes follicle during the developmental stages is given in the Table (Table 1).

Implantation of early 4th and 5th instar testes into newly moulted adult males and females : Early 4th and 5th instar testes were implanted into newly moulted adult males and females. The implants remained in the host for 11 days in the case of 4th instar testes and for six days in the case of 5th instar testes, as this was the period normally taken by 4th and 5th instars respectively to become adults. Controls were those implanted into 4th and 5th instar nymphs as the case may be. Implants recovered after this period showed that differentiation proceeded and sperms were found in all the recovered testes (Figs. 4, 5 and 6). However, the growth of the testes was retarded in all cases including those of the control implanted into nymphs when compared to testes normally growing in the animal. The testes implanted into female hosts grew better than those implanted into males.

Implantation of 4th instar testes into allatectomized females : At the termination of the experiment the implant remained for five days and ten days respectively in the allatectomized animal after 1st and 2nd implantation respectively. Testes implants did not show any growth in size or progress in germ cell differentiation at the end of 1st implantation or even at the end of 2nd implantation (Fig. 7) into allatectomized animal. On the other hand, the controls implanted into sham–operated animals showed well developed spermatids and sperms (Fig. 8).

In order to investigate how these 4th instar testes, which were implanted successively twice into allatectomized adult females, subsequently responded when implanted into normal adult female containing JH. the testes recovered from allatectomized females after two implantations lasting for a period of ten days in them, were implanted

into normal newly moulted adult female. These implants after remaining in the normal adult environment for five days, developed spermatids and sperms and reached a stage comparable to that of the 5th instar testes (Fig. 9).

Effect of juvenile hormone analogues : Fourth instar nymphs topically applied with FME/LWM moulted into 5th instars and subsequently into supernumerary, 6th instars. Control animals moulted into normal adults. Testes of the supernumerary (6th instars) resulting from FME treatment topically, had larger testes with more loosely arranged sperms when compared to the controls (Figs. 10 & 11). However, tesets of supernumerary nymphs resulting from LWM did not show this difference ; they were comparable to those of the controls. Injection of FME into either 4th or 5th instar also did not show any difference from those of the controls with regard to testes structure and development.

Effect of ecdysterone : The early 4th instar nymphs injected ecdysterone in single dose or double dose moulted into 5th instar and subsequently into normal adults within 11-12 days just as controls. Their testes did not show any difference from normal adult testes.

The early 4th instar testes implanted into newly moulted adult females and treated with ecdysterone in single or double dose also did not show any distinct difference from that of the controls.

DISCUSSION

Recent studies have shown that in Lepidoptera ecdysone plays a very important role in spermatogenesis. Thus, it was found that fusion was induced in vitro in the testes of *Ephestia kühniella* by ecdysone (NOWOCK, 1973). Spermatogenesis in the silkworms *Hyalophora cecropia* and *Samia cynthia* depended on ecdysone (SCHMIDT & WILLIAMS, 1953), though it was subsequently shown that a macromolecular factor was necessary for differentiation into spermatozoa (WILLIAMS & KAMBYSELLIS, 1969) and ecdysone played a permissive role (KAMBYSELLIS & WILLIAMS, 1971 b). In *Chilo supressalis* also spermatogenesis occurred in vitro, with the addition of ecdysterone (YAGI et al., 1969). spermatocytes developed into spermatids in *Monema flavescens* only after addition of ecdysterone, in vitro (TAKEDA, 1972). WILLIAMS & KAMBYSELLIS (1969) however obtained spermatogenesis in vitro without ecdysone in free spermatocytes, and concluded that the hormone acted by altering the permeability of the testis wall permitting a macromolecular factor to enter the testes. On the other hand in the blood sucking bug *Rhodnius prolixus* testes exhibited a basal level of division activity in the absence of any morphogenetic hormone, though ecdysone doubled this mitotic index (DUMSER & DAVEY, 1975). They also found that the juvenile hormone analogue farnesyl methyl ether showed no effect on the basal level of mitotic index in the testes, though it abolished the ecdysone induced enhancement of the mitotic index of the testes. Though in the milkweed bug *Oncopeltus fasciatus* topical application of the JH analogue Bower's compound (6,7–epoxy–3, 7–dimethyl —oct–2–enyl ether of p–carbomethoxy phenol) to immature instars resulted in juvenilisation after subsequent moult and supernumerary instars, it had no effect on testes differentiation (ECONOMOPOULOS & GORDON, 1971). They also found that the sperm differentiation also took place when immature testes were implanted into adult males and females of *Oncopeltus*. Our present studies also show that in *Dysdercus cingulatus* differentiation of spermatocytes into sper-

matids and sperms took place when immature testes were implanted into adult male and female of the species. We find in addition, that this differentiation does not take place if the adult female hosts are allatectomized before implantation of testes. However, further differentiation of the spermatocytes will proceed without hindrance, if the immature testes implanted into allatectomized adults are again reimplanted into normal adult females with intact corpus allatum. Since the adult males do not withstand allatectomy, these experiments have not been performed in the males. Our experiments involving implantation into allatectomized adults show that an intact corpus allatum is necessary for differentiation of spermatocytes into spermatids and sperms. Exogenous FME topically applied to nymphs also appear to stimulate the process, though its injection and treatment with LWM did not show any effect. The stimulating effect of corpus allatum does not appear to be mediated through nutritive milieu, as it has been found in our laboratory that allatectomy does not affect either food intake or digestive enzymes (amylase or protease) of the animal (MURALEEDHARAN, 1977). This is in contrast to the findings in *Drosophila hydei* (RINGGER-BRANDLE, 1976) in which testes cultured in well-fed hosts produced more cysts and grew larger than those cultured in hosts kept on standard diet. It appears that JH is necessary for this differentiation in *Dysdercus cingulatus*. This is in apparent contrast to the role of JH in testes differentiation in *Rhodnius prolixus* (DUMSER & DAVEY, 1975) where it does not affect the basal level of mitotic index but even inhibits ecdysone induced enhancement of mitotic index. In *Galleria exigua* larvae also corpora allata retarded testes development (SEHNAL, 1968). Our studies on *Dysdercus cingulatus* involving topical application and injection of the JH analogues FME and LWM are rather not so clear cut: testes of the supernumerary nymphs resulting from topical application of FME had larger testes with more loosely arranged sperms when compared with controls whereas the testes of supernumerary nymphs resulting from LWM did not show this difference. Injection of FME or LWM also did not show any difference in testes characters from that of the controls. Possibly the JH titre required for this feature is higher. The larger size of the testis with more loosely arranged sperms at the basal region appear to be a sign of maturation of the sperms as this is the change taking place from the early fifth instar to the adult moult. We have found that always the implanted testes were smaller than the normal testes developing intact. Apparently, this is not due to deficiency of JH alone, as testes removed from early nymphs of the same age, also shows this peculiarity. This could be due to separation of the connection of the testes from the vas deferens as for *Drosophila* (STERN, 1941) or alternatively, due to lack of growth due to separation of tracheal connection and nonavailability of sufficient oxygen as suggested by ECONONOMOPOULOS & GORDON (1971) in *Oncopeltus fasciatus*. It may be noted that our studies do not indicate any role for ecdysone for further differentiation of spermatocytes as injected ecdysterone did not produce any effect on the testes implanted in the nymphs or in the adult. It may also be noted that the prothoracic glands in *Dysdercus cingulatus* appear to be inactive in the adult of this species though they still persist for some time (Joseph & PRABHU, 1977). In addition, ecdysone from other sources is also likely to be absent in the normal adult of this species, as its presence due to exogenous administration (JOSEPH & PRABHU, 1977; JALAJA et al., 1976) or due to implantation of active prothoracic glands (JOSEPH & PRABHU, 1977) leads to ovarian degeneration. It may be noted that DEMAL & LELOUP (1972) believe that the effect of ecdysone

noted by WILLIAMS & KAMBYSELLIS (1969) and by YAGI et al., (1969) was because the insects used by them were in diapausing stage at the time of explantation. However, the possibility of this hormone playing a role in earlier stages cannot be ruled out from the present studies. Recent studies on *Drosophila* (RUNGGER-BRANDLE, 1976) also show ecdysone's effect on germ cell division. In *Periplaneta americana* however, BLAINE & DIXON (1970) found that neither prothoracic glands nor neurosecretory cells affected development of testes though the corpora allata maintained the testes in juvenilised stage by retarding their development. They also do not preclude the possibility of either the neurosecretory cells or prothoracic glands affecting the testis development at a still earlier stage (earlier than 7th instar) in this animal. Equally possible is the role of the neurosecretary cells in this animal in spermatogenesis. These aspects have not been looked into during the present investigation.

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EFFECT OF TIME OF SOWING ON INCIDENCE OF PESTS AND PLANT CHARACTERS OF *HIRSUTUM* COTTON VARIETY 320 F

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The jassid (*Amrasca biguttula biguttula* (ISHIDA) and budmoth (*Phycita infusella* MEYR.) attack increased with delayed sowings. March and April sown crop produced stress flowers in June which provided a good substrate for the early multiplication of pink bollworm (*Pectinophora gossypiella* SAUND.). Pink bollworm attack on loculi basis did not vary significantly in different plantings. Very early and late sown crop carried more overwintering pink bollworn larvae through seed. Early sown crop was tall, with more and broader leaves. Halo length remained unchanged in all the dates of sowing. Seed-cotton yield decreased significantly in June and July sowing dates.

(*Key words :* **jassid, *Amrasca biguttula*, budmoth, *Phycita infusella*, pest attack, sowing time**)

INTRODUCTION

The normal recommended sowing period for cotton in the western zone of the Punjab is from mid-April to end of May. As the cotton sowing period coincides with the harvesting and threshing of wheat, the farmers continue sowing even up to end of June. Some studies on the effect of sowing dates on the population of jassids and on various plant characters in different varieties of cotton were carried out by KAIRON (1968) in Haryana and by AGARWAL (1973) in Delhi. The present investigation involves the study of cotton pests along with yield and its ancilliary characters as influenced by the dates of sowing.

MATERIALS AND METHODS

Nine sowing dates selected were March 7, 14, 27, April 3, 19, May 23, June 8, 18 and July 4. Randomised block design with three replications was adopted. Single line was the unit plot in the experiment. Three plants at random from each plot were tagged for observations on plant height, total number of leaves, leaf area, monopods, halo length, total bolls, jassid (*Amrasca biguttula biguttula* (ISHIDA) injury grade, bolls and loculi damaged by pink bollworm (*Pectinophora gossypiella* SAUND.), stained *kapas* and carryover of pink bollworm larvae. Carry-over through seed was studied by taking 100 g seeds from each plot just after the final pick was over. Population of whitefly (*Bemisia tabaci* GENN.) and thrips (*Thrips tabaci* LIN.) was recorded from 3 fully formed green leaves per plant. Bud moth (*Phycita infusella* MEYR.) incidence and yield were recorded on plot basis. All the plots were kept completely unsprayed throughout the crop season.

RESULT AND DISCUSSION

Attack of thrips, whitefly and jassid

Population of thrips and whitefly (adults) remained low in different dates of plantings. Crop sown from March to May, escaped the jassid attack while jassid injury grade II appeared in the plots sown on June 8 and grade III in the plots sown on June 18 and July 4 during the last week of August (Table 1). These studies corroborate the findings of KAIRON (1968) and AGARWAL (1973).

TABLE 1. Effect of sowing dates on jassid injury grade, damage and carryover of pink bollworm in *hirsutum* cotton variety 320 F.

Sowing date	Jassid injury grade	Pink bollworm incidence *			Pink bollworm larvae *	
		Bolls attacked (%)	Loculi damaged (%)	Stained kapas (%)	Sticks	Seed
March 7	I U	98.2ab	73.6abc	71.9a	1.3	70.56bc
March 14	I	99.6b	82.0bc	77.6cd	2.6	67.24bc
March 27	I	90.0ab	78.4abc	81.6d	3.8	32.49a
April 3	I	99.2ab	79.5abc	81.5d	5.8	37.21a
April 19	I	94.9a	69.5ab	76.3bc	5.3	40.96ab
May 23	I	99.2ab	83.1c	70.9abcd	9.4	47.61ab
June 8	II	97.0ab	71.8abc	63.4ab	7.4	65.61 bc
June 18	III	94.8a	67.6a	66.4abc	10.7	75.69c
July 4	III	95.1a	73.3abc	68.5abc	1.8	59.29abc
Statistical Significance ($p=0.05$)		S	S	S	N S	S

*Statistical analysis was done using angualr transformation in pink bollworm incidence and by $\sqrt{n+1}$ in larval population transformation.

Jassid injury grade I : Entire foliage free from crinkling or curling with no yellowing, bronzing, browning and drying of leaves.

Jassid injury grade II : Crinkling, curling of a few leaves mostly in the lower portion of the plant and a little yellowing of leaves.

Jassid injury grade III : Crinkling and curlirg of leaves almost all over the plant and growth hampered.

Attack of bud moth

The incidence of bud moth on plant basis was 2, 4, 4·4, 2·0, 5·0, 4·4, 4·3, 19·7, 46·4 and 81·1 per cent in the plot sown on March 7, 14, 27, April 3, 19, May 23, June 8, 18 and July 4, respectively during last week of September. The bud moth attack appeared to be more on short plants. It was 20 and 30 times more in the plots sown on June 18 and July 4, respectively, as compared with plots sown on March 7.

Attack of pink bollworm

Stress flowers appeared quite early in June in all the plots sown in March and April. Two to three bolls per plot opened in end of June which were attacked by pink bollworm resulting in their rottings. Pink bollworm moths emerging early in the season which otherwise die due to lack of fruiting bodies for feeding were able to breed on the stress flowers and bodies.

The percentage bolls damaged by bollworm were significantly more in the plots sown on March 14 being at par with plantings of March 7, 27, April 3, May 23 and June 8. Significantly higher loculi infestation was observed in plantings of May 23 which was at par with other plantings except those of April 19 and June 18. Stained *kapas* was significantly more in plots sown on March 27 and April 3 being at par with the plantings of March 14 April 3 and 19 (Table 1). The heavy attack in all the plots may be attributed to the moth migration. The studies carried out in the United States of America (ANONYMOUS, 1969) also showed that a wide range in planting dates in an area extends the reproduction period of the crop on helping in the multiplication of the pink bollworm.

Carryover of overwintering pink bollworm larvae

Carryover through sticks did not vary significantly in different plots while through

TABLE 2. Various plant characters and seed cotton yield of 320 F as influenced by varying sowing dates.

Sowing date	Height/plant cm	Leaves/plant No.	Area leave sq m	Monopods/ plant No.	Bolls/plant No.	Halo length mm	Seed-cotton yield q/ha
March 7	242b	413d	5.65d	3.7cd	63c	23.2	25.91d
March 14	273g	506e	6.60de	4.1cd	67c	23.7	21.25cd
March 27	281h	512e	7.49e	4.0cd	63c	22.6	21.44cd
April 3	258b	402d	4.55c	5.0d	42bc	23.1	22.28cd
April 19	213e	574e	5.84d	8.5e	88d	23.2	21.07cd
May 23	194d	282c	3.41bc	3.4cd	38b	24.0	23.14d
June 18	117b	140b	1.23a	1.5ab	34ab	23.4	12.96b
July 4	63a	45a	3.50bc	0.2a	15a	22.2	8.35a
Statistical significance (p=0.05)	S	S	S	S	S	N S	S

Statistical analysis was done using $\sqrt{n}$ transformation

seed it was more in very early and very late plantings i.e., March 7, 14, May 23, June 8, 18 and July 4 sowing dates (Table 1). The work done in the United States of America (ANONYMOUS, 1969) shows that diapausing larval population was much greater in the late than in the early plantings.

Plant height, total number of leaves and leaf size

Maximum plant height of 281 cm was recorded in the plots sown on March 27 which was at par with height in plots sown on March 14. The plant height started decreasing significantly in the plot sown on April 19 and afterwards (Table 2). The greater plant height in the early sown plots becomes unsuited for conventional insecticidal sprays and picking. The total number of leaves per plant were also significantly more in the plots sown on March 14, 27 and April 19. Leaves decreased significantly in June and July sown plots. Leaf area was also more in early sown plots.

Monopods and halo length

Monopods did not vary significantly in the plantings of March, April 3 and May 23 (Table 2). Maximum monopods were recorded in the plots sown on April 19. The halo length remained uniform in all the sowing dates. RAJARAMAN & AFZAL (1943) also observed that sowing dates extending from 15th April to 1st July did not affect the halo length. Similar findings were also obtained by SIMLOTE *et al.* (1967).

Bolls per plant and seed-cotton yield

Plots sown in March and April (except sown on 3rd April) had greater boll population, their number being significantly more in the plots sown on 19th April. The yield per plot did not vary with planting dates extending from March to May. Seed-cotton yield decreased significantly in the June and July sowing dates. These findings are in agreement with those of TROUGHT & AFZAL (1931). However, SIMLOTE *et al.* (1967) found that 30th April is the optimum sowing date for American cotton under irrigated conditions in northern Rajasthan.

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CLEPTOPARASITISM OF THE FIG WASPS (TORYMIDAE: CHALCIDOIDEA) IN *FICUS HISPIDA* L.

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Observations are given on the nature of relationships between the agaonid, *Ceratosolen marchali* MAYR and the two torymids, *Philotrypesis pilosa* MAYR and *Apocrypta bakeri* JOSEPH, all three breeding in the receptacles of *Ficus hispida* L. Both *Philotrypesis* and *Apocrypta* females which are provided with long ovipositors deposit their eggs only in those *Ficus* ovaries containing the eggs and the poison injected by the *Ceratosolen* female while ovipositing. In such instances of parasitisation, either one egg of *Philotrypesis* only or that of *Apocrypta* only, is found developing along with one egg of *Ceratosolen*. The larval development showed parasitic behaviour; out of the two larvae found in the same ovary, one is always active and feeds on the other larger inactive larva. The shapes of the larval mandibles differ in the three species of insects involved. The adult organisation is also influenced by the parasitic mode of life; in the females of *Philotrypesis* and *Apocrypta*, the poison glands are much reduced and they are therefore solely dependent on the poison secreted by the female *Ceratosolen* (which is provided with well developed poison glands) for bringing about the development of a suitable melieu inside the *Ficus* ovaries for their own larval development. The unisexual variations met with in the males of these torymids are also attributed to this cleptoparasitic mode of life.

(Key words : **cleptoparasitism, fig wasps,** *Ficus hispida*, *Ceratosolen marchali*, *Philotrypesis pilosa*, *Apocrypta bakeri)*

INTRODUCTION

The symbiotic mutualism that exists between the various species of *Ficus* and their syconia-inhabiting insects of the family Agaonidae, is well known. These insects successfully breed in the *Ficus* ovaries while the plants depend exclusively on them for cross pollination. However, the relationship between the *Ficus* species with various other species of fig wasps, mainly belonging to the family Torymidae, is not properly understood. Similarly, very little information is available on the exact relationship between the torymids and the agaonid species concerned and on the nature of the relationship among the different genera of torymids themselves breeding inside the syconia of a given *Ficus* species. The biology of many species of such torymid insects remains unknowns. RAVASINI (1911), LICHTENSTEIN (1919), HAGAN (1929) and others while studying the caprification phenomenon in *Ficus carica*, mentioned the occurrence of the torymid, *Philotrypesis caricae* along with the agaonid pollinator, *Blastophaga psenes*. Many regarded *P. caricae* and *B. psenes* as co-inquilines, while a few regarded the former as a parasite of the latter. GRANDI (1930) proposed that *P. caricae* may be a cleptoparasite of *B. psenes*. JOSEPH (1957,1958 & 1959) has conclusively shown that *P. caricae* is a cleptoparasite of *B. psenes*. The larva of this *Philotrypesis* species was shown to be phytophagous and devours the endosperm of *F. carica*. Having attained its second stage, it destroys the *Blastophaga* larva, by more active feeding. The present study on the nature of the interrelationship between the wasps inhabiting the syconia of *Ficus hispida* L. is more compli-

cated by the presence of one more torymid species, *Apocrypta bakeri* JOSEPH, besides the agaonid, *Ceratosolen marchali* MAYR, and a torymid, *Philotrypesis pilosa* MAYR.

MATERIALS AND METHODS

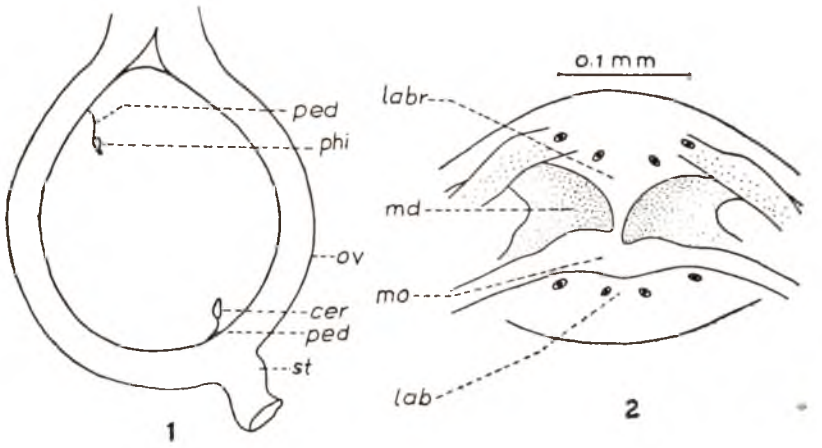
Collection of figs containing insects in different stages of development were regularly taken to the laboratory. Gall flowers from these figs were dissected in physiological solution under the stereomicroscope to observe the eggs and various stages of larvae of the three types of insects. Adult females of the torymids that were reared in the laboratory were utilized to study the oviposition behaviour in the different batches of tender figs provided for oviposition from time to time. The females of the three species were dissected in physiological solution to study the structure of their reproductive organs.

OBSERVATIONS AND DISCUSSION

As is well known, manner and the milieu of oviposition characterize an insect as either freeliving or parasitic. The females of both *Philotrypesis pilosa* and *Apocrypta bakeri*, which are provided with long ovipositors deposit their eggs by inroducing their ovipositors through the fig wall into the fig ovaries, into which *Ceratosolen marchali* has already laid an egg and injected a little of the secretion of its acid gland. This acid secretion is considered to be the factor essential for initiating the parthenogenetic development of the endosperm of the *Ficus* ovaries which then provided the food and the milieu necessary for the growth of the insect larva. The presence of this 'internal host factor' is probably detected by the sensillae located on the tip of the ovipositors of these torymids. When tender figs free of *Ceratosolen* eggs were supplied to the ovipositing females of *Philotrypesis* and *Apocrypta*, although they readily attempted to oviposit, this did not lead to the final act of oviposition and no eggs were deposited inside such fig ovaries. This observation leads to the conclusion that the two torymid wasps do not lay their eggs in those ovaries wherein *Ceratosolen* has not oviposited and that the factor determining the successful oviposition by *P. pilosa* and *A. bakeri* is the presence of the acid secretion injected by *C. marchali* into the *Ficus* ovaries after egg deposition.

There is no possibility of superparasitism or of multiparasitism in these torymid wasps, as in all cases of parasitization only two types of eggs were found in a single ovary, one always being that of *Ceratosolen*, having its characteristic shape and position nearer the style region and the other egg either that of *Phylotrypesis* or of *Apocrypta* (Fig. 1).

Direct evidences on the exact relationships involved among the three wasps breeding in *F. hispida* could be obtained from a study of their larval developments. When the *Ficus* ovaries in the appropriate condition were examined for the wasp larvae, several of them were found to contain two larval forms developing side by side. Out of these, one (torymid larva) was found to be more active (with its wriggling movement and the feeding movements of the mandibles) than the other (larva of *C. marchali*). The *Ceratosolen* larva was found to be rather inactive, though it was in some instances even larger than the torymid larva. The active larva always was identified as either *P. pilosa* or *A. bakeri*, based on the nature of their mouth parts (Figs. 2, 3 & 4). When the two larvae (the agaonid host larva and the torymid parasite larva) have reached their respective second instars, and as the mount of food in the *Ficus* ovary diminishes, the active parasite larva more effectively feeds on the availabe food. This probably leads to the starvation of the more inactive agaoind larva (cleptoparasitism). When the whole of the available food in the fig ovary is exhausted by this competitive feeding,



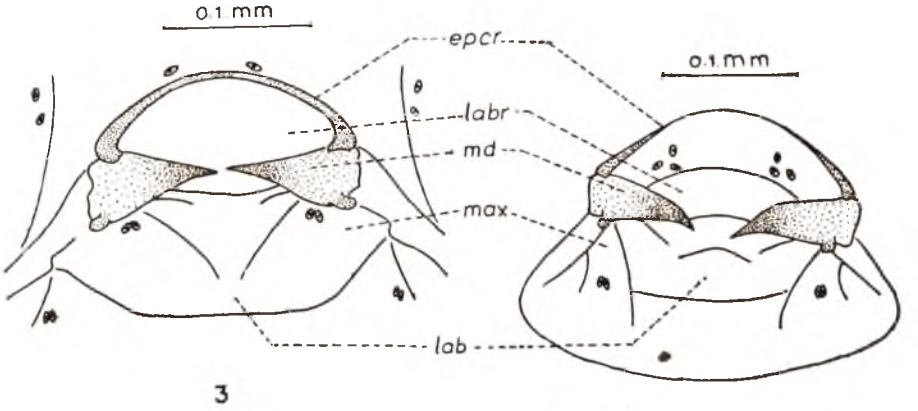
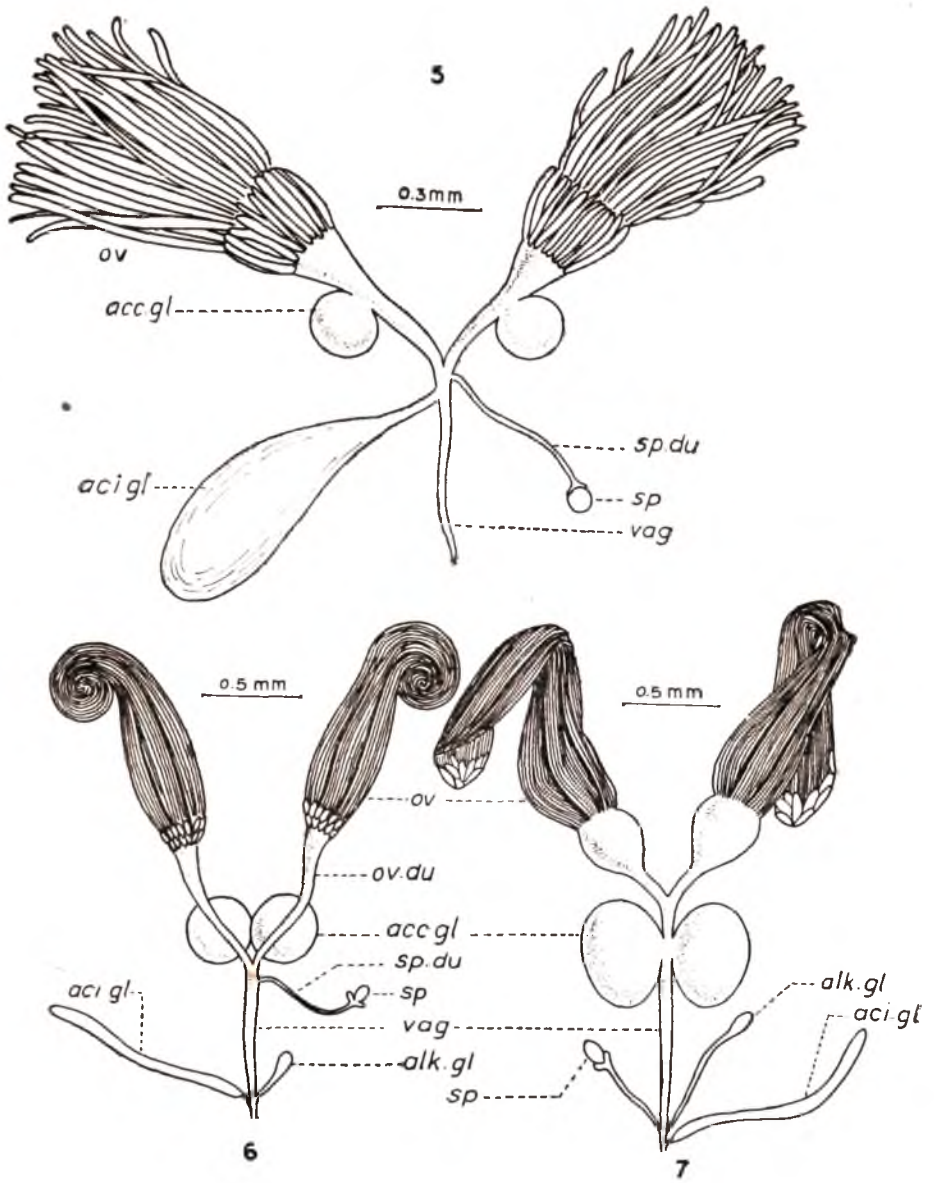


Fig. 1. The location of the eggs of the agaonid and the torymid inside the *Ficus* ovary.
Figs. 2–4. Mouth parts of the second stage larvae of *C. marchali* (Fig. 2), *P. pilosa* (Fig. 3) and *A. bakeri* (Fig. 4).

ABBREVIATIONS USED

cer – *Ceratosolen egg* ; eper – epicranial crest ; labr – labrum ; lab – labium ;
md – mandible ; max–maxilla ; mo–mouth ; ov – ovary ; ped – peduncle ;
phi – *Philotrypesis* egg ; st–style.



Figs. 5–7. The female reproductive organs of *C. marchali* (Fig. 5), *P. pilosa* (Fig. 6) and *A. bakeri* (Fig. 7).

ABBREVIATIONS USED

acc. gl – accessory gland; aci. gl – acid gland; alk. gl. – alkaline gland; ov–ovarioles; ov. du – oviduct; sp–spermatheca; sp. du – spermathecal duct; vag – vagina.

it is possible that the parasite larva pierces the body wall of the host larva and thus kills it. Several such cases could be observed, the parasite larva sometimes found remaining colsely adhered to the body of the host larva with its wrinkled integument and shrunken body.

There is reason to think that the cleptoparasitic mode of life of the fig-inhabiting torymids may have brought about the atrophy of the acid glands in the adult females and the unisexual size variations in the males, and that it can influence the sex-ratio. The presence of a well-developed acid gland associated with the reproductive system in the female of *Blastophaga psenes*, and the atrophied nature of the same in the cleptoparasite, *P. caricae*, have been already cited by GRANDI (1930), and its significance pointed out by JOSEPH (1958 & 1959). Similarly, the females of *C. marchali* are provided with highly developed acid gland associated with their reproductive system (Fig. 5). In the females of both *P. pilosa* and *A. bakeri*, these glands are greatly atrophied (Figs. 6 & 7). The two torymid species, therefore, solely depend upon the acid secreted by the host *C.marchali*, for inducing the parthenogenetic development of the endosperm of the *Ficus* ovary.

The unisexual size variations in these torymids can be attributed, as explained by JOSEPH (1958), to their cleptoparasitic mode of life. In cases where the parasites have deposited their eggs in such fig ovaries where the host larvae have attained considerable growth, the newly emerged parasitic larvae are left with an insufficient quantity of food. This quantity can vary from ovary to ovary depending on the period which the *Ceratosolen* larva was alive. This results in the development of the parasitic larvae of varying sizes. Since the size of the adults depends directly on that of the larvae, individuals with size variations are finally produced. The existence of a differential mortality of the sexes as a result of partial larval starvation has been shown in the parasitic Hymenoptera (GENIEYS, 1925). GROSCH (1948) indicated that haploidy permits animals to survive better under such conditions of starvation than in the case of the diploid individuals. Most of the females (diploid), under such conditions, will be eliminated, while the males (haploid) survive as dwarf individuals. This is precisely the reason why unisexual size variations are more commonly seen in the males of fig-inhabiting torymids than in their females.

Under the same conditions leading to the production of the unisexual size variations, the cleptoparasitic mode of life involving partial larval starvation, leads to a differential mortality of the sexes with less of diploid females surviving than the haploid males. This may result in an appreciable modification of the sex-ratio expressed as an augmentation in the number of males with respect to that of the females.

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ESTIMATION OF ALDICARB AND PHORATE RESIDUES IN CAULIFLOWER

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Side dressing of aldicarb and phorate at the rate of 1.5 kg ai/ha after 5 days of transplanting of cauliflower seedlings resulted in the mean deposits of 15.4 and 21.6 ppm in soil respectively. Aldicarb persisted in soil for 90 days whereas the persistence of phorate residues was only for 60 days. The uptake of aldicarb in curd of cauliflower was more than 0.2 ppm at 60 days interval, however, phorate residues could not be detected in curd.

(Key words : **residue estimation, cauliflower, aldicarb, phorate)**

INTRODUCTION

Among the various pests of cauliflower the aphid, *Lipaphis erysimi* KALT causes serious damage (YADAV & SACHAN, 1976). Its curds are used as vegetable and leaves as fodder for domestic animals. The systemic insecticides are being commonly used for the control of aphids. Recently GUPTA & KAVADIA (1977) found soil tratment of aldicarb, disulfoton and phorate at the rate of 1 and 2 kg ai/ha effective in controlling mustard aphid. In view of consumer's safety, the residues of systemic insecticides like aldicarb and phorate were estimated in soil, leaves and curd of cauliflower.

MATERIALS AND METHODS

The experiment was conducted in a randomised block design at Horticulture Farm of College of Agriculture, Udaipur during August-October, 1977. The cauliflower (variety-*Indian snow boll*) seedlings were transplanted in plots measuring 8m×6m with a row to row and plant to plant distance of 0.6 m. Aldicarb 10 G and phorate 10 G were applied in furrows as side dressing at the rate of 1.5 kg ai/ha ,after 5 days of transplanting. Each treatment was replicated thrice including control.

The samples of soil (upto 10 cm depth), leaf and curd were collected randomly from each replicate at definite time interval (Table 1). For both the insecticides, distilled cholroform at the rate of 4 ml/g sample was used as solvent. The extraction of insecticides from soil samples was done by tumbling on motorised shaker for 30 minutes. The supernatent extract was filtered through a Whatman No. 1 filter paper and collected in reagent bottles. Leaf and curd samples were chopped and macerated in the Warring blender using distilled chloroform as solvent at the arte of 3 ml/g sample. The extract was filtered under pressure through a scintered funnel containing a thin layer of hyflo-supercel and anhydrous sodium sulfate placed over a Whatman No. 1 filter paper There was no need of cleanup of soil extract whereas for leaf and curd extract 0.5 g nuchar C-190 N(activated charcoal) per 50 ml extract was added in a beaker which was shaken for 30 seconds. Filtration was done through Whatman No. 1 filter paper. Two to three washings each with 10 ml of chloroform was given to the residues in the beaker and filtered. Thus all the filtrates were pooled together and residues of aldicarb and phorate were estimated.

The spectrophotometric technique (MD[1]–UC–21149–II) supplied by Union Carbide was used for aldicarb determination. Phorate residues were estimated using GETS & WATT's (1964) method. The recoveries of both the insecticides from soil and plant ranged between 90–93 per cent.

TABLE 1. Residues of aldicarb and phorate in soil and cauliflower plant.

Days after application	Aldicarb (ppm)			Phorate (ppm)		
	soil	leaf	curd	soil	leaf	curd
0	15.40	..	..	21.60	..	..
15	6.50 (57.78)	2.40	..	5.75 (73.38)	1.75	..
35	3.09 (79.93)	BDL	1.97	0.48 (97.77)	BDL	BDL
60	1.69 (89.02)	BDL	0.45	BDL (100.00)	BDL	BDL
90	BDL (100.00)	..	..	..	..	..

BDL—Below detectable level; figures in parenthesis represent percentage reduction.

RESULTS AND DISCUSSION

Aldicarb

It is evident from Table 1 that aldicarb granules applied in furrows at the rate of 1.5 kg ai/ha after 5 days of transplanting resulted in 15.4 ppm initial deposit in the soil. The quantum of residues 15 days later was 6.5 ppm which resulted in the loss of 57.78% from the soil. However, the residues of aldicarb was below the detectable level at 90 days interval. DIKSHIT *et al.* (1976) also reported the persistence of aldicarb in soil upto 80 days. The residues of aldicarb translocated in leaves from soil was 2.4 ppm at 15 days interval and below detectable level at 35 and 60 days intervals. The translocation of residues in the curd at 35 and 60 days intervals was 1.97 and 0.45 ppm respectively. Thus curd at harvest contained the residues more than the tolerance limit of 0.2 ppm.

Phorate

The initial deposits of 21.6 ppm in soil dissipated by 73.38, 97.77 and 100 per cent in 15, 35 and 60 days interval (Table 1). SING & GULATI (1971) however, showed 1.87 ppm of phorate in soil even after 93 days of its application at a rate of 100 μg/g. There was evidence of translocation of residues from soil to leaves at 15 days interval which amounted to 1.75 ppm but on other intervals, the residues could not be detected in leaves and curd. Thus the application of phorate can safely be done in the soil after transplanting of cauliflower.

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DAMAGE POTENTIAL OF SHOOTFLY, *ATHERIGONA APPROXIMATA* MALLOCH ON PEARL MILLET, *PENNISETUM TYPHOIDES* STAPE AND HUBB

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The damage potential of shootfly, *Atherigona approximata* on pearl millet indicated that dead heart formation observed upto 21 days alone might cause reduction in yield.

(*Key words :* **damage potential, shootfly, *Atherigona approximata*, pearl millet, *Pennisetum typhoides***)

INTRODUCTION

The shootfly, *Atherigona approximata* MALLOCH, unlike other shootflies causes damage to shoots causing 'dead hearts' as well as to the peduncle of the earhead resulting in drying up of earheads with little or no seed setting. SINGH & JOTWANI (1973) estimated that the pest caused an avoidable loss of at least 35.3 per cent in grain yield with effective treatments. However, SANTHARAM *et al.* (1977) did not get any significant increase in yield though the incidence could be reduced from 46.4 to 16.8 and 14.3 to 3.9 per cent of dead hearts and grain head injury respectively by applying carbaryl plus phosphamidon. Hence, it was considered necessary to find out the relation between dead heart, grain head injury and yield so as to economise the plant protection operation.

MATERIAL AND METHOD

Two field experiments were conducted one each with cumbu UCH_4 and Co.6 varieties in simple randomised replicated design with three replications. The crop was protected after allowing the crop for pest attack for different periods. Thus seven variants were included. In one, the crop was protected for the entire crop growth and in another, the crop was not at all applied with insecticides throughout the crop period. In the remaining five variants, the crop was protected after certain time viz., 14, 21, 28, 35 and 42 days after germination and the protection afforded was continued till harvest.

To protect the crop from fly attack, disulfoton (Disyston 5G) granules were applied at the rate of 0.6 g ai/metre row in soil and carbaryl 0.1 per cent ai (Sevin 50 WP) plus phosphamidon 0.1 per cent ai Dimecron 100 EC) were given as floliar spray. To ensure maximum control of the shootfly, not considering the cost of the chemical, the soil and foliar applications of insecticides were repeated at 15 day interval.

To facilitate easy movements for taking various observations on individual plants wider spacing of 60×22.5 cm was adopted. Each plot consisted of 5 rows of 15 plants each. The observations were restricted to 30 marked plants in the central three rows leaving the border plants and border rows.

The fly incidence was assessed by counting the total shoots and those showing dead hearts. The affected shoots were tagged. The count was continued at weekly intervals. At the time of harvest, total number of earheads emerged from affected shoots, and the earheads showing fly injury and grain and straw yield were recorded.

RESULTS AND DISCUSSION

Application of disulfoton and carbaryl plus phosphamidon had definitely reduced the fly incidence effectively as reported by SAN-

TABLE 1. Percent of grain heads emerged from shoots affected by shootfly at different stages.

Days upto which the crop was unprotected	Co. 6						UCH_4				
	2nd week	3rd week	4th week	5th week	6th week	Total	2nd week	3rd week	4th week	5th week	Total
Completely protected	..	..	0	0	0	0	0	..	22.2	0	18.3
14	0	0	25.0	7.9	0	6.7	0	0	47.6	11.1	21.7
21	0	0	22.2	9.2	14.3	0	0	0	52.2	20.5	18.9
28	0	4.4	22.2	10.3	0	8.7	0	21.0	34.8	3.0	20.9
35	0	44.4	11.1	10.4	8.3	12.2	33.3	20.8	24.5	19.6	14.9
42	..	33.2	18.1	33.3	2.4	27.5	11.1	14.3	27.0	8.7	26.1
Completely unprotected	0	0	58.3	27.2	2.4	20.5	8.3	52.4	25.1	8.4	22.2

0 Dead heart observed, but earheads not emerged.

— No dead heart observed.

THARAM *et al.* (1977), the reduction being high with extended period of protection with these toxicants. The incidence was high in Co.6 when comapared to that in UCH_4 as evidenced from both dead heart as well as earhead injury. This might be due to longer exposure of Co.6.

The earhead emergence was not affected by the dead heart injury (Table 1). The per cent of earheads emerging from shoots affected by the fly is fairly high during fourth week followed by third and fifth week. This is due to the fact that tillers produced at all stages are attacked by the fly but those formed at later stage are not productive irrespective of the fact whether they are attacked by fly or not. Those in early stages are so tender that they wither off due to dead hearts. Those tillers which are in intermediary stages find sufficient time to produce earheads depending upon the intensity of the fly attack and plant vigour to prevent the fly injury from reaching the growing point.

Similarly the dead hearts formed did not have any relation to the earhead injury as the per cent of grain heads with fly injury out of earheads emerged from fly affected shoots varies from 0 to 33.3 and 0 to 16.7 in Co.6 and UCH_4 respectively. The extent of earhead injury within the grain head varies from 2 to 100 per cent. Unless the extent of this damage is very high, the earhead injury may not affect the yield. In the present case, the extent of damage was not high, hence this might not have reduced the yield.

It is concluded that the deadheart formation observed upto 21 days might cause reduction in yield. After this stage, the deadheart injury observed does not seem to affect total tillers and grain head production

TABLE 2. Effect of crop protection for different periods on fly incidence, total tillers, grain heads and yield (Mean of 3 observations—Figures in parentheses are transformed values)

Days upto which the crop was not protected with insecticides	Co.6						UCH_4					
	Dead hearts	(%) Grain head injury	Total tillers (no)	Total grain heads (no)	Yield (kg) per plot		Fly incidence (%)		Total tillers (no.)	Total grain head (no)	Yield (kg) per plot	
					Grain	Straw	Dead heart	Grain head injury			Grain	Straw
Completely protected	3.7 (10.6)	3.8 (11.1)	208	86.7 (42.7)	1.23	6.83	1.4	0.9	267	108 (38.1)	1.00	5.73
14	6.7 (14.9)	15.9 (16.8)	193	83.0 (42.7)	1.23	7.32	4.3	7.7	279	108 (40.8)	0.90	5.93
21	13.7 (21.7)	8.8 (16.8)	179	83.0 (51.6)	1.33	6.92	10.6	1.3	256	114 (45.9)	1.08	6.92
28	15.3 (22.7)	14.1 (21.8)	227	87.0 (43.2)	1.32	7.08	9.0	1.9	276	103 (42.3)	1.05	5.97
35	14.4 (22.3)	11.9 (11.2)	168	78.3 (42.6)	1.83	7.07	16.4	2.6	252	103 (42.4)	1.05	6.25
42	23.3 (28.3)	11.2 (19.1)	176	83.3 (45.4)	1.30	6.97	12.8	3.2	233	110 (41.9)	1.05	6.13
Completely unprotected	25.9 (30.5)	14.8 (22.6)	143	85.7 (46.3)	1.20	6.87	17.4	4.7	264	98 (52.6)	1.00	5.57
S E	(2.4)**	(1.0)	11*	N S	N S	N S	1.1**	N S	N S	N S	N S	N S
C D	(7.3)	(3.2)	34				3.4					

* Significant at 5% ** Significant at 1% N S Not significant

(Table 2). Hence the plant protection measures are to be aimed at checking this pest in early stage of the crop.

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RELATIVE EFFECT OF SOME INSECTICIDAL TREATMENTS ON CONTROL OF THE MAIZE STEM BORER

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The efficacy of nine insecticides, applied by seed-furrow (aldicarb and phorate 10 G at 1.5 g/m; disulfoton 5 G, mephosfolan 5 G and carbofuran 3 G at 3 g/m) ; seed-dressing (carbofuran 5% and phorate 2%) and foliar spray (monocrotophos 0.04% and endosulfan 0.05%) was evaluated against stem borer, *Chilo partellus* (SWINHOE) on hybrid maize. The observations were recorded on percentage infestation 17, 24, 31, 38 and 45 days after germination and on fodder yield, plant height, tunnel length, number of tunnels, larval and pupal population inside tunnel at the time of harvest. The results revealed that seed-furrow application with mephosfolan 5 G applied at the rate of 3 g/m row gave the effective control of the miaze stem borer. Carbofuran granules proved next best to mephosofolan in efficacy. The foliar spray and seed-dressing treatments proved to be ineffective against this pest.

(*Key words :* **Control of maize stem borer, *Chilo partellus***)

INTRODUCTION

The stem borer, *Chilo partellus* (SWINHOE) is one of the major pests and limiting factors in the production of hybrid maize. NOOR & KUSHWAHA (1967) found that 3 triweekly sprays of endosulfan starting 3 weeks after germination were most effective and economical in controlling this borer. BASKARAN (1972) reported side-dressing of mephosfolan was better than carbofuran. CHATTERJI *et al.* (1972) reported that mephosofolan and carbofuran 10% granules applied 17 and 34 days after sowing in the soil gave best control of maize stalk borer. Recently, AGRAWAL *et al.* (1977) found endosulfan 0.05% spray most effective and economical for the control of this borer.

With a view to explore the possibilities of controlling the stem borer, the present investigations were undertaken to test the efficacy of different insecticides applied as foliar spray, seed-dressing and seed furrow.

MATERIALS AND METHODS

The experiment was laid out at the Agronomy Farm, Rajasthan College of Agriculture, Udaipur in randomised block design. The seeds of hybrid 'Ganga 5' were dibbled 15 cm apart in 4 metre long furrow spaced at 50 cm distance. There were nine different insecticidal treatments besides control, each replicated thrice (Table 1). The granular insecticides were applied into the opened furrows and stirred with a stick before sowing the seeds. In case of seed-dressing treatment, the required quantity of insecticide was thoroughly mixed with the seeds using gum arabic as sticker. The foliar spray treatment was given 10 days after germination. In order to assess the relative efficacy, observations on the number of infested plants including dead hearts were recorded at weekly interval, starting from 17 days after germination on the basis of visible symptoms of borer injury. The effect of treatments on fodder yield, plant height, tunnel length, number of tunnels, larvae and pupae per plant was recorded at the time of harvest by uprooting and splitting the plants in each replicated row. The data thus obtained were subjected to analysis of variance.

RESULT AND DISCUSSION

Percentage infestation of plants

It is evident from Table 1 that all the insecticidal treatments were significantly superior over control at all the intervals except at 24 days where phorate G and phorate seed-

treatment were comparable with control. The percentage infestation of plants was minimum (0 to 20.73) in mephosfolan G treatment at all the intervals. At 17 days interval, carbofuran seed-treatment was next to mephosfolan G whereas carbofuran G treatment was second at 24, 31 and 38 days interval and monocrotophos spray, which is at par with carbofuran G, comes second at 45 days interval. The phorate seed-treatment proved ineffective for borer control. Rest of the insecticidal treatments were intermediate in effect.

Post-harvest observations

Fodder yield : The maximum yield (7.42 kg) was obtained in case of carbofuran G treatment which proved significantly superior over all the treatments. The treatment of mephosfolan G stood second however, it was comparable with disulfoton G, monocrotophos spray, endosulfan spray, carbofuran seed and phorate G treatments. The minimum yield (3.25 kg) was obtained in case of aldicarb G which is comparable with control.

Height of plants : The maximum plant height (123.53 cm) was recorded in carbofuran G treatment which was at par with mephosfolan G and seed treatment. The difference in rest treatments were, however, not significant. There was no significant difference between control and phorate seed-treatment.

Tunnel length : The insecticides have shown significant effect over control. The minimum length (2.01 cm) was recorded in mephosfolan G treatment which is comparable to carbofuran G, and monocrotophos spray treatment as against 4.71 cm length in control. The tunnel length in case of remaining treatments ranged between 2.61 to 4.08 cm.

Number of tunnels : The treatment of mephosfolan G and carbofuran G proved to be effective but are comparable with carbofuran seed, disulfoton G, monocrotophos spray and phorate G treatments, in which the number of tunnel was less than one. The treatment of phorate seed was at par with control.

Larval population : The minimum larval population (0.77 /plant) was recorded in carbofuran granular treatment followed by mephosfolan G (0.81) and it was significantly superior to both phorate G and seed and aldicarb which were non-significant to control (1.03). The treatment of carbofuran G proved equally effective with remaining treatments and they were also at par with phorate and aldicarb treatments.

Number of pupae : Mephosfolan G and carbofuran G proved best insecticides which were at par with carbofuran seed, disulfoton, endosulfan, monocrotophos, phorate G, aldicarb and phorate seed treatments were equally effective, however, phorate seed treatment was comparable to control.

Thus it is concluded that seed furrow application of mephosfolan granules gave excellent control of maize stem borer as compared to seed treatment with carbofuran, phorate and foliar spray with endosulfan and monocrotophos. However it was closely followed by carbofuran granules applied in the soil. Since the shootfly attack is not severe in this region as compared to stem borer, thrips and whitegrubs, therefore, soil application of mephosfolan granules will also be helpful in controlling the whitegrub as evidenced by KUSHWAHA & NOOR (1976) against *Lachnosterna serrata*. None of the treatments had any deleterious effect on the germination of seeds. The present findings are in agreement with that of BASKARAN (1972) who reported that side-dressing with mephosfolan proved better than carbofuran and other 12 granular insecticides in controlling the sorghum stem borer, though it was

TABLE 1. Effect of different insecticides on the control of *C. partellus* (SWINHOE).

	Dose	Mean percentage infestation (days after germination))					Fodder yield per row (Kg)	Plant hieght (cm)	Tunnel lenght per plant (cm)	Number of tunnels per plant	Number of larvae per plant	Number of pupae per plant
		17	24	31	38	45						
Seed-furrow (g/m row)												
Aldicarb 10 G	1.5	9.50	19.34	28.04	31.35	27.23	3.25	96.33	2.61	1.05	0.93	0.81
Carbofuran 3 G	3.0	7.78	14.26	21.64	24.65	23.26	7.42	123.53	2.02	0.93	0.77	0.71
Disulfoton 5 G	3.0	9.57	18.81	25.05	28.52	25.40	5.50	102.73	4.08	0.97	0.83	0.75
Mephosfolan 5 G	3.0	0.0	7.78	17.52	20.73	19.09	5.53	117.63	2.01	0.93	0.81	0.71
Phorate 10 G	1.5	10.82	20.84	25.35	28.72	26.54	5.03	98.33	3.11	1.01	0.91	0.79
Seed-dressing (per cent)												
Carbofuran	5.0	6.29	17.56	24.90	27.79	25.28	5.10	114.13	3.03	0.96	0.83	0.73
Phorate	2.0	15.78	21.63	29.84	31.59	34.96	4.83	88.33	3.20	1.15	0.91	0.85
Foliar spray (per cent)												
Endosulfan 35 EC	0.05	11.38	20.18	25.55	31.28	29.79	5.10	106.26	2.87	1.05	0.85	0.77
Monocrotophos 40 EC	0.04	9.46	19.29	23.49	28.22	23.24	5.13	110.43	2.26	0.97	0.83	0.77
Control	–	13.43	21.82	33.87	36.69	35.93	3.42	81.96	4.71	1.22	1.03	0.95
C D at 5%	–	0.14	1.49	0.59	0.30	0.50	0.59	10.81	0.30	0.08	0.13	0.11

relatively less effective against the shootfly when compared to carbofuran. CHATTERJI *et al.* (1972) also obtained significantly lesser damage of the maize stem borer with mephosfolan and carbofuran 10 G applied 17 and 34 days after sowing in the soil at the rate of 2.5 kg/ha.

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EFFECT OF STARVATION ON ORGANIC CONSTITUENTS OF THE MILLIPEDE *SPIROSTREPTUS ASTHENES* (POCOCK)[1]

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The level of total lipids of haemolymph of the millipede *Spirostreptus asthenes* shows consistent decreasing trend during starvation (studied at 15, 30 and 45 day periods). The levels of other organic constituents studied show recoveries after initial decreases. Except total proteins the other organic constituents studied in the fat body show decreasing trends, the decreases for the shortest (15 day) starvation duration being steep. Starvation metabolism of this millipede appears to be lipid-oriented.

(*Key words :* **Starvation metabolism, millipede, fat body, haemolymph, organic constituents**)

INTRODUCTION

The metabolism during starvation was investigated in arthropod groups like Crustacea (RAMAMURTHI & VIRABHADRACHARI, 1975), Insecta (WIGGLESWORTH, 1949) and Arachnida (REDDI & SELVARAJAN, 1975).

In myriapods starvation stress has begun to be studied (SATYAM *et al.*, 1977). The present communication deals with the effect of starvation on the organic constitutents of haemolymph and fat body of the millipede *Spirostreptus asthenes*.

MATERIAL AND METHODS

The millipedes collected from fields around Kodur 45 km from Tirupati, were maintained in individual glass vivaria and fed *ad libitum* with cabbage leaves during the sojourn in the laboratory. Intermoult males were subjected to starvation stress through 15, 30 and 45 day durations.

The weight of each millipede was determined prior to starvation (pre-starvation weight) and at the end of the specific period, just prior to sacrifice (post-starvation weight). Haemolymph was collected from a syringe-needle-stab wound on the head. The fat body adhering to the body wall was scraped, collected in entirety, dried, weighed *en masse* and used for the chemical analyses.

In the fat body and haemolymph the following organic constituents were estimated : total carbohydrates (TCHO) and glycogen by the method of CARROLL *et al.* (1956) ; total proteins (TP) according to LOWRY *et al.* 1951) ; total ninhydrin-positive substances (TNPS) according to MOORE & STEIN (1957) ; and total lipids (TL) according to FOLCH *et al.* (1957).

RESULTS AND DISCUSSION

In both haemolymph (Table 1) and fat body (Table 2) of the millipede it is the level of lipids that shows consistent decrease through the starvation regime. In haemolymph, all the constituents decrease during the shortest starvation period, the change in protein content (-4.9%) being minimal (Table 1). For the other durations of

[1] Part of doctoral thesis of P. Satyam submitted to Sri Venkateswara University, Tirupati, 1976.

TABLE 1. Organic constituents of haemolymph of *Spirostreptus asthenes* during starvation. (Values, mg/100ml^{-1}, are mean ± standard deviations; number of determination given in Table 2).

Constituent	Days of starvation			
	0	15	30	45
Total carbohydrate	57.9± 4.76	42.1± 1.58	30.4± 3.15	52.9± 2.93
Total protein	2870± 355	2730± 686	9180± 912	4890± 304
TNPS (Total ninhydrin positive substances)	863± 50.7	590± 88.2	902± 101	1125± 74.1
Total lipid	2824± 146	622± 14.6	734± 13.0	746± 15.6

TABLE 2. Organic constituents of the fat body of *Spirostreptus asthenes* during starvation (Values are g/100g dry wt^{-1}).

Constituent	Days of starvation			
	0	15	30	45
Total protein	a41.95±2.54	31.24±3.59 (19.7)	35.41±1.05 (19.5)	35.26±1.63 (19.21)
TNPS	2.57±0.153	1.11±0.186 (0.70)	1.35±0.265 (0.74)	1.34±0.245 (0.72)
Total carbohydrates	1.59±0.252	0.93±0.302 (0.59)	0.59±0.156 (0.33)	0.58±0.102 (0.31)
Glycogen	0.16±0.019	0.11±0.038 (0.07)	0.09±0.025 (0.05)	0.09±0.018 (0.05)
Total lipid	45.78±1.91	25.05±1.03 (15.7)	16.34±1.12 (9.01)	13.25±1.09 (7.18)

a: Values are mean ± standard deviation; number of animals used : 0 days, 10; 15 days, 5; 30 days, 5; 45 days, 6. Values shown in parentheses are based on pre-starvation dry weight of fat body according to EMERSON (1967). The dry weight of the fat body is 62.92, 55.16 and 55.10% pre-starvation weight at the end of 15, 30 and 45 day starvation periods respectively.

starvation, the different constituents show different trends. The total protein (TP) content of haemolymph shows remarkable elevations whereas TNPS content rises less notably. The level of total carbohydrates (TCHO) shows a progressive decrease upto 30 days of starvation and by 45 days a recovery occurs so that the TCHO content at the end of this duration is as much as 91.4% control. The total lipid content shows the steepest change by 15 days and for the subsequent periods of starvation relatively small changes are evident as compared to the 15 day starvation level. Thus the changes in the organic composition of haemolymph reveal recoveries in the levels of the constituents except total lipids after prolonged starvation ; this may suggest that the starvation metabolism of the millipede is oriented towards lipid.

The changes in the levels of organic constituents of fat body (Table 2) give evidence for the involvement of lipid in starvation-energetics. During the first fifteen days of deprivation of food, both protein and lipid, which happen to be the two abundant constituents of the fat body, show equal and consi derable decreases. Later, the level of TP continues unmodified while TL content continues to decrease. The fat body has been found to show decrease in weight during starvation (SATYAM, 1976). If this gravimetric decrease is considered for recalculation of the levels of organic constituents (for discussion see EMERSON, 1967), the changes in the levels of these constituents appear more conspicuous (see Table 2). The lipid orientation of fat body metabolism during starvation also becomes more explicit.

The patterns of changes in the levels of organic constituents of the body fluid and fat body of *S. asthenes* conform to a considerable extent to WIGGLESWORTH'S summary for the bio-chemistry of insect starvation (WIGGLESWORTH, 1949). Especially the rate of utilization of lipid and its quantitative preponderance in the insect and millipede may be noted with interest. In *Locusta migratoria* during five days of starvation there is a decrease in fat body lipid content (JUTSUM *et al.*, 1975).

JUTSUM *et al.* (1975) have noted an increase in the haemolymph lipid concentration at the end of five day starvation duration. This may suggest mobilization of fat body lipid into haemolymph during the period of food deprivation. This hyperlipaemia renders lipid orientation interpretation rather tenuous in the case of insect. But, in the millipede the lipid content decreases not only in the fat body but in the haemolymph also during the initial (0–15 day) starvation period. This may be an unequivocal demonstration of the lipid orientation of starvation metabolism of the millipede.

The gross energetics during starvation may be met by lipid as well as protein, in the millipede (see above). However, the other minor constituents also appear to contribute to some extent to the starvation energetics. Important changes in the activity of catalytic machinery for catabolism of various constituents may, therefore, be expected (SATYAM *et al.*, 1977). This 'liberalism' of utilization of various organic constituents in the millipede during starvation may be compared to the situation obtaining in other arthropod groups (RAMAMURTHI & VIRABHADRACHARI, 1975; REDDI & SELVARAJAN, 1975).

The constancy of lipid level in haemolymph of *S. asthenes* during prolonged starvation is similar to a phenomenon noted in *L. migratoria* after five days of starvation (JUTSUM *et al.*, 1975). WLODAWER & WISNIEWSKA (1965) studied the starvation metabolism of wax moth and postulated a lipaemia regulatory mechanism during insect starvation.

Similar mechanisms may be operating in the starving millipede.

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MORPHOLOGY OF THE EXTERNAL AND INTERNAL GENITAL ORGANS OF FEMALE *SPHYRACEPHALA HEARSEIANA* WESTW. (DIOPSIDAE : DIPTERA)

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The external genitalia in the female is reduced and is represented only by paired triangular lobe-like vulva guarding the genital pore. The internal organs of reproduction in the female comprises a pair of ovaries, a pair of lateral oviducts, a median oviduct and the vagina which opens into the genital chamber. The genital chamber opens to the exterior through the gonopore. A single ovary contains 8 to 10 ovarioles bound together in a thin peritonial membrane. There are three spherical spermathecae opening into the vagina through short ducts.

(*Key words :* **Female external and internal genitalia,** *Sphyracephala hearseiana*)

INTRODUCTION

The Diopsidae, popularly known as "Stalked eyed flies" are a group of morphologically interesting flies. They are abundantly availaable during November to February in and around Agra. They are usually found where there is shade, damp or wet soil and lush vegetation. The notable work on the female genitalia of Diptera are by HUCKETT (1921), DAVIS (1926), GERRY (1932), HADORN & GLOOR (1946), REES & ONISHI (1951), SASAKAWA (1958), RANADE (1961), NAYAR (1965), IPE (1966) and by DEGRUGILLIER & LEOPOLD (1973) on the internal genitalia of the female housefly, *Musca domestica* L. This paper deals with the functional morphology of the reproductive organs of the female *Sphyracephala hearseiana* WESTW.

MATERIAL AND METHODS

Techniques employed for the study of genitalia are the same as described in earlier apaper, KUMAR (1978).

RESULTS AND DISCUSSION

External Genitalia (Figs. 1 & 2)

The ovipositor in *S. hearseiana* is a very simple type without any special structural formations. There is no telescoping ovipositor as in the case of *M. obtusa* (IPE, 1966) and *Syrphus balteatus* (NAYAR, 1956). The female genital pore is seen at the intersegmental membranous region of 7th and 8th segment. It is an oval opening guarded on either side by a triangular lobe-like structure, the vulva. The vulva is covered by numerous bristles. The postgenital sternal portions are membranous. The two cerci are seen attached on the distal ends of the 8th sternum which too is more or less membranous.

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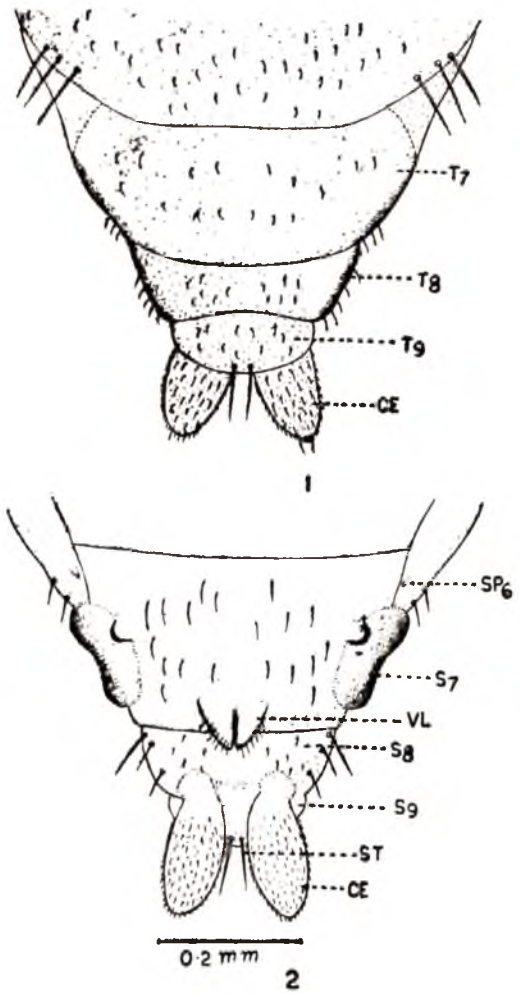


1. Dorsal view of female genitalia. 2. Ventral view of female genitalia.

Internal Organs of Reproduction

The reproductive organs of the female include paired ovaries, a pair of lateral oviducts, a single median common oviduct and the vagina which opens into the genital chamber through the gonopore. In addition to these, are present three spermathecae. In the case of *S. hearseiana*, there are no accessory glands.

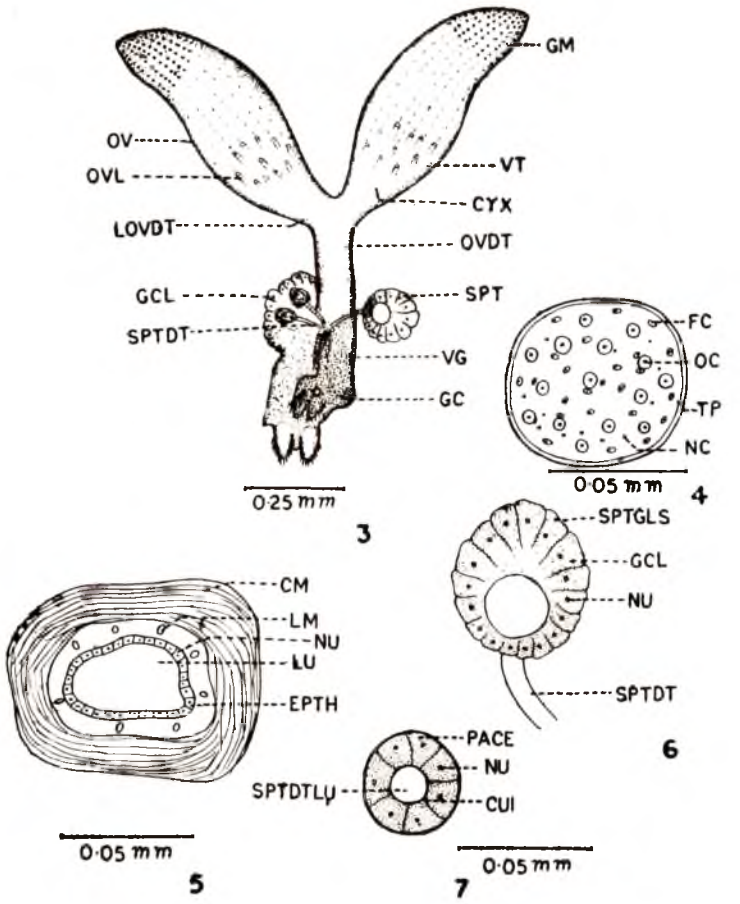
Ovaries (Figs. 3 & 4)

Ovaries when mature lie in a ventrolateral dosition in the body cavity on either side of the alimentary canal, extending from the fifth to the posterior border of the first abdominal segments, giving the abdomen a swollen appearance. Externally they are covered over by numerous fat cells and is abundantly supplied by tracheae. The mature ovaries measure about 0.64 mm in length roughly 0.36 mm in thinkness at their widest region.

Ovarioles or egg tubes : On an everage about eight to ten egg tubes or ovarioles constitute a single ovary, and these are bound together by a thin peritonial membrane. The ovarioles taper distally and are swollen at the basal regions. The swollen basal region measures about 0.36 mm in width. Three distinct regions can be differentiated in the ovarioles, a basal portion containing mature oocytes (corresponding to pedicel portion), a middle swollen vitellarium containing actively multiplying undifferentiated cells and a very short undifferentiated terminal filament.

The wall of the ovariole is composed of a thin structureless membrane, the "tunica propria," which is considered by some workers as a sheet of connective tissue. The vitellarium representing the largest portion of the ovariole, is further differentiated into 8 to 10 egg chambers, each egg chamber containing an outer layer of follicular cells, surrounding the nurse cells and the oocytes at the various stages of development. The germarium tapers anteriorly and contains germ cells towards its anterior side. Unlike in *M. obtusa* (IPE, 1966) and *S. balteatus* (NAYAR, 1965), no distinct terminal fialmant is formed in this case.

The lateral oviduct : Lateral oviduct (Fig. 3) or 'ductus lateralis' is a short tube of more or less uniform diameter 0.14 mm wide and 0.2 mm long. Its anterior end is slightly enlarged to form a cup-shaped calyx into which the mature oocytes are received. In a



3. Internal reproductive organs of the female; 4. T. S. of the ovary; 5. T. S. of the common oviduct; 6. Spermatheca; 7. T. S. of the spermathecal duct.

ABBREVIATIONS USED

CE–Cerci., CM–Circular muscle ; CUL–Cuticular intima ; EPTH–Epithelium ; FC–Follicle cell ; GC–Genital chamber ; LM–Logitudinal muscle ; LOVDT–Lateral oviduct ; LU–Lumen ; NC–Nurse cell ; NU–Nucleus ; OC–Ooyte ; OV–Ovary ; OVDT–Oviduct ; OVL–Ovariole ; PACE–Pavement epithelium ; S7-S9–Sternites ; SPT–Spermatheca ; SPTCT–Spermathecal duct ; SPTGLS–Glandular cells of the spermatheca ; SPTDTLU–Lumen of the spermathecal duct ; ST–Setae ; T7-T9–Tergites ; TF–Terminal filament ; TP–Tunica propria ; VG–Vagina ; VL–Vulva ; VT Vitellarium.

transverse section the single layered epithelial lining seems to be thrown into folds for facilitating expansion during the pssage of eggs. Each lateral oviduct lies ventrally in the fifth abdominal segment and unites medially in the anterior part of the sixth abdominal segment with its counterpart from the other side to form the common median oviduct or 'oviductus communis'.

Common oviduct and genital chamber : The median oviduct lies medially in the sixth

and seventh abdominal segments and opens posteriorly into a short thick-walled vagina or genital chamber lying in the eighth abdominal segment. The latter opens to the exterior by the female genital aperture at the junction of the 7th and 8th sterna. The median oviduct measures about 0.22 mm in length. The genital chamber or atrium is a pyriform muscular, swollen pouch with thick spinous intimal lining and is formed in the posterior part of the genital segment or eighth segment by the folding of the intersegmental membrane between the seventh and eighth segments on the ventral side. The common oviduct is demarcated from the genital chamber by the opening of the spermathecal ducts.

The common oviduct (Fig. 5) is enveloped in a thick circular layer of muscles. Besides the muscular layer, internally the epithelial layer is quite distinct with flat cells and indistinct nuclei. The epithelial layer is thrown into irregualr longitudinal folds, the inner surface of the epithelium being lined by fairly thick cuticle. The cytoplasmic contents of the epithelial cells are granular with distinct nuclei. The existence of inner cuticle lining the lateral oviducts suggests their ectodermal origin. DOBZHANSKY (1930) and MILLER (1950) also contributed to the same idea. NAYAR (1965) reported in *S. balteatus* the presence of intimal lining in the lateral oviducts and supported the views of DOBZHANSKY (1930) and MILLAR (1950). SNODGRASS (1935), however, suggests the oviduct as having been secondarily replaced by ectodermal material in higher insects.

Spermathecae : The sphermathecae (Figs. 3 & 6) are three, spherical, dark brown, highly chitinized, ball-like structures of about 0.2 mm diameter, lying dorsally in the sixth abdominal segment, close to the common oviduct. Each spermatheca is invested with a thick coat of fat cells and the two sphermathecae of the left side are almost joined to one another by their fat layers. A narrow duct of about 0.04 mm diameter and 0.16 mm in length connects each of them with the vagina.

The longitudianl and transverse sections (Fig. 7) show that the spermathecae have got a single layer of glandular epithelial cells externally and internally, and a thick intima which has become a cup-shaped chamber for the storage of sperms. The cells are finely granular with prominent nuclei. The spermathecal ducts, from both sides, unite to form a common duct just before opening into the vagina. The epithelial lining external to the thick cuticle is bounded externally by a thin basement membrane. There is no trace of any muscle layer.

The anterior swollen spherical portion shows large glandular cells with very prominent nuclei. The lumen is very much reduced due to the large size of the cells. There is no muscular layer but the gland cells are arranged on a thin basement membrane.

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OBSERVATIONS ON THE FEEDING HABITS OF SOME SOIL COLLEMBOLA FROM AN ABANDONED FIELD IN KERALA

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Study of the gut contents of three species of soil Collembola viz., *Alloscopus tetracantha* BORNER, *Microparonella duodecemoculata* PRABHOO and *Cyphoderopsis decemoculata* PRABHOO collected from an abandoned field revealed both qualitative and quantiative differences with overlap in the type of materials consumed by these species indicating that these insects were capable of food selection. *A. tetracantha* mostly fed on amorphous substance and higher plant material, *C. decemoculata* on amorphous substance and spores of the fungi *Curvularia* and *Cordana* plus an unidentified fungal spore and *M. duodecemoculata* on amorphous substance and spores of the fungus *Epicoccum* and of another unidentified fungal species. A large number of individuals under each species were with empty gut as they were in the nonfeeding phases of the intermoult period. Tentatively it may be said that 33–54% of *A. tetracantha*, 50–89% of *M. duodecemoculata* and 33–77% of *C. decemoculata* at any time of the year would be in the nonfeeding phase in the field.

(Key words : **Collembola, food, moulting, fungi)**

INTRODUCTION

Several studies on Collembola have shown that these insects are found in a variety of terrestrial habitats and that in certain types of soil they are also found in very large numbers often reaching a density of several thousands per square meter. Under the humid tropical conditions of Kerala they have been found to exist not only in large numbers but they also showed considerable species diversity in the same habitat (PRABHOO, 1976). One of the questions that would naturally arise on taxonomic and ecological studies of Collembola in any habitat would be as to whether several species coexisting in a habitat could have identical food sources.

Few early investigators like AGRELL (1940) thought that Collembola were unspecialised feeders because individuals of the same species in two localities showed very different items of food in their gut. BELLINGER (1954) thought that due to the small size of their mouth parts the Collembola might feed mostly on the microflora. PACLT (1956) considered unicellular algae, moss and fungal hyphae to be the more common food items of these insects. POOLE (1959) stated that although the most important item of food of Collembola to be fungus, decaying plant remains and detritus, the larger species fed on fungal material, predominantly hyphae and smaller species on humus. CHRISTIANSEN (1964) provided an excellent review of the studies on the food of Collembola.

The present study was undertaken in order to bring to light the food of three species of Collembola living together in a habitat to see whether, under field conditions, they showed any food preference and whether their food sources were identical.

METHODS EMPLOYED

Surface soil along with litter was collected from an abandoned field in the University campus. Soil samples were extracted using a series of Berlese-

Tullgren funnels and the Collembola were collected in 70% ethyl alcohol. For studying the gut contents, simple methods were described by KNIGHT & ANGEL (1967) and DE WITH & JOOSSE (1971). For the quantitative estimation of the particles ANDERSON & HEALEY (1972) described an elaborate technique in which the gut contents in water were repeatedly frozen and thawed and the dispersed particles stained lightly. MASSOUD & NAJIT (1976) recently dealt with in general the techniques employed in studying the feeding habits of Collembola. In the present study individuals of the three species of Collembola viz., *Alloscopus tetracantha* BORNER, *Microparonella duodecemoculata* PRABHOO and *Cyphoderopsis decemoculata* PRABHOO fixed in 70% ethyl alcohol were mounted directly in polyvinyl alcohol (SALMON, 1954). The insects became highly transparent in this medium within a week's time. The food band and the particles in it were also rendered sufficiently clear making it possible for their categorization. The categorization of the particles was made as recommended by KNIGHT & NAGEL (1967). Relative abundance of the various materials in the food band was assessed on an area basis by drawing the food bands on a graph paper using camera lucida. Stage in the moult cycle was determined based on the nature of the cuticle (DE WITH & JOOSSE, 1971 ; THIBAUD, 1976).

OBSERVATIONS AND DISCUSSION

All the species studied possessed mandibles provided with incisors and well developed molar areas. The individuals of the three species were collected from the field on several occasions from October to December 1976 and from June to July 1977, no animals being obtained in the interverning period.

The materials in the gut could be classified into four broad categories viz., higher plant particles, fungal materials, amorphous substance and mineral particles (Table 1). The fungal materials were hyphae and spores. The relative proportion of the various substances in the gut contents varied in the three species. KNIGHT & ANGEL (1967) thought that the amorphous substance in the gut of *Tomocerus* species they studied, was a mixture of dietary components which had undergone partial digestion. If this was true then *A. teracantha* and *C. decemoculate* fed mostly on amorphous substance which formed 69% of their gut contents. The techniques of ANDERSON & HEALEY (1972) would exclude this amorphous substance and hence would be inadequate for the study of the gut contents of the species treated here. In addition to the amorphous substance *A. tetracantha* fed on higher plant material which formed about 24% of the gut contents and also a little of the fungal material, almost completely composed of fungal hyphae (Fig. 1 A). *C. decemoculata* on the other hand preferred fungal spores to higher plant material, the former amounting to 30% of the gut contents (Fig. 1 B). Higher plant material was found to be very low forming 1% of the gut contents. The remarkable difference noted in the feeding habits of *M. duodecemoculata* was

TABLE 1. Mean percentage of various food items in the gut contents of Collembola collected from an abandoned field.

Name of species	% higher plant material	% fungal material	% amorphous substance	% mineral particles	Size of commonly found food particles in/μm
A. tetracantha	24	6	69	1	18.2×13
C. decemoculata	1	30	69	traces	15×3.6
M. duodecemoculata	3	66	31	traces	18.2×10.4

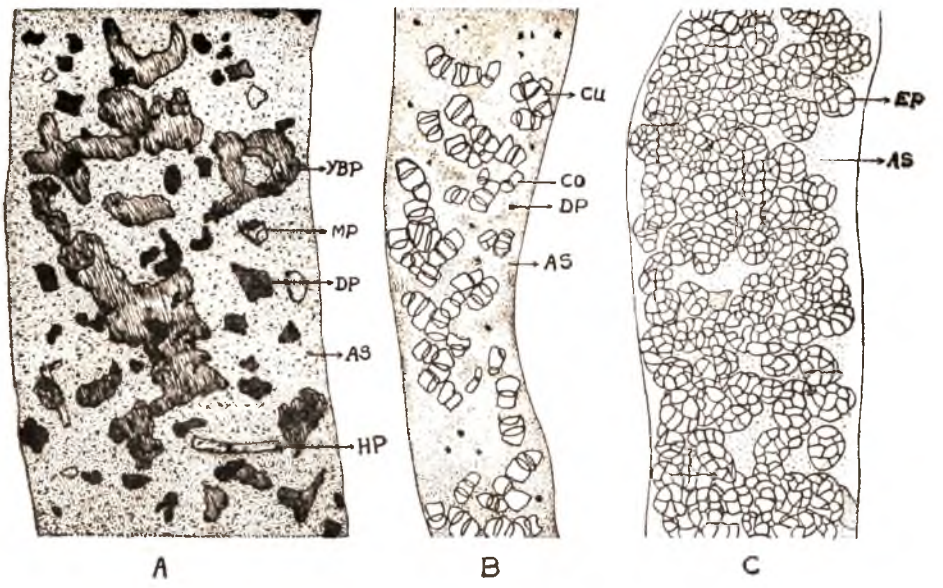


Fig. 1. Relative abundance of food materials in the gut contents. A *Alloscopus tetracantha* BORNER. B. *Cyphoderrosis decemoculata* PRABHOO, C. *Microparonella duodecemoculata* PRABHOO. AS—Amorphous substance ; Co—Spore of *Cordana* ; Cu-Spore of *Curvularia* ; Dp—Dark particles of higher plant origin; Ep—Spore of *Epicoccum* ; Hp—Hyphal fragment; YBP—Yellowish brown particle of higher plant origin, MP—Mineral particle.

that this species fed mostly on fungal spores (Fig. 1 C) which formed 66%, the amorphous substance forming 31% and materials of higher plant origin only 3% of the gut contents. None of the species consumed mineral matter to any appreciable quantity. In *A. tetracantha* mineral matter formed only 1% and in others only traces of this were found in the gut contents. Although both *M.duodecemoculata* and *C.decemoculata* fed on fungal spores, in the former species the spores of *Epicoccum* and of an unidentified species were found (Figs. 2 and 3), while in *C. decemoculata* the spores of *Curvularia* and *Cordana* and another unidentified species of fungus were found (Figs. 4 and 5).

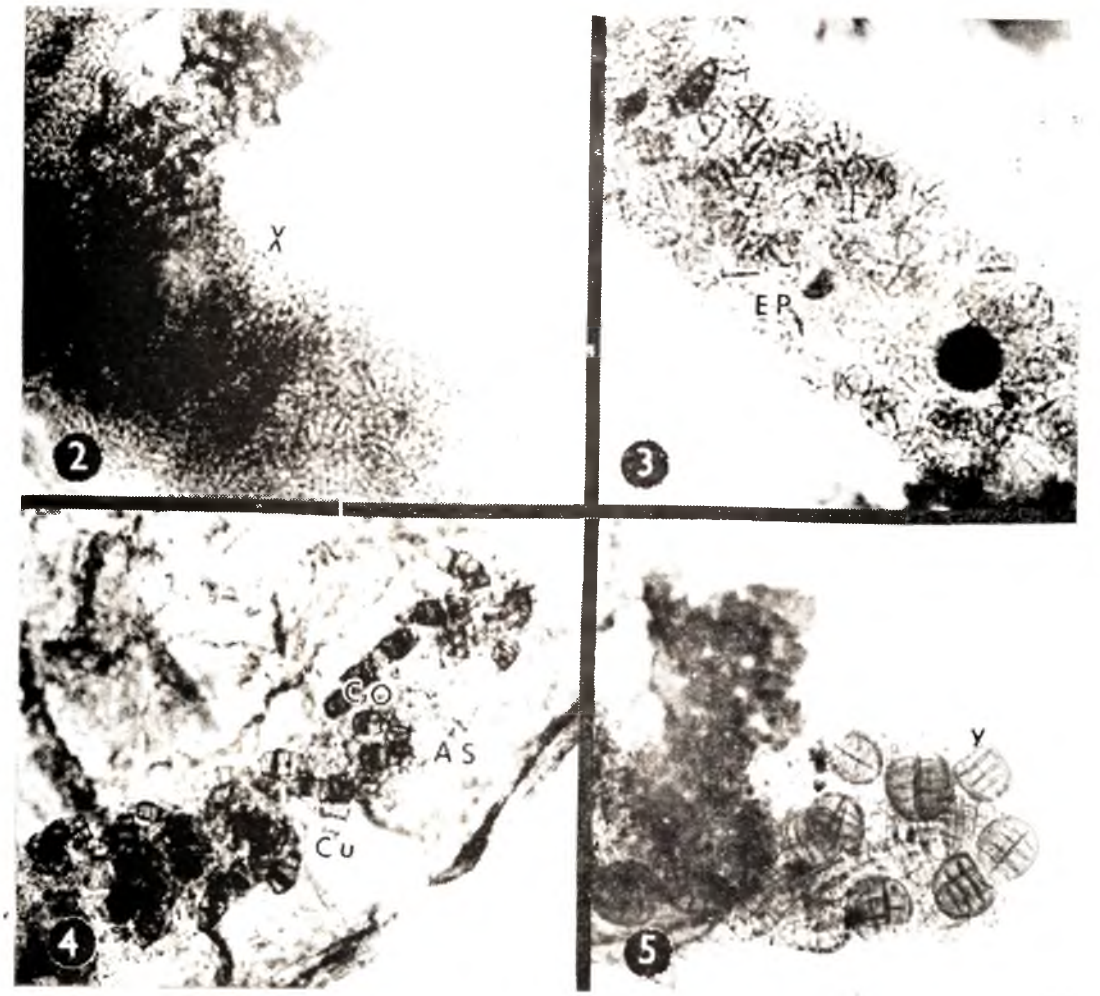
It appeared from this study that in spite of the considerable overlap in the food materials of the species living in the same place it was unlikely that the food sources of the two species would be completely identical. Display of this food differences by related species sharing habitats appeared to be in agreement with the general ecological concepts (DE BACH, 1966) and and findings on oribatid mites in Kerala (HAQ & PRABHOO, 1976). The evidence presented here showed that the generalization that detritivore Collembola are unspecialised feeders (HALE, 1967) is untenable when it is reasonably presumed that the small percentage of higher plant material found in the gut of *Microparonella* and *Cyphoderopsis* and the fungal material in the gut of *Alloscopus* was due to accidental intake rather than due to deliberate feeding. Apparently while some Collembola could feed on higher plant material others are likely to thrive more on fungal material

than on other substances as predicted by BELLINGER (1954) and CHRISTIANSEN (1964).

Yet another aspect of feeding in Collembola is its interruption by periodic moults occurring throughout their life. Table 2 shows that in all the three species some individuals showed microscopically visible gut contents and in others the gut was empty. The latter category was 39% in *A. tetracantha* 59% in *C. decemoculata* and 82% in *M. duodecemoculata*. This phenomenon was observed by earlier workers and CHRISTIANSEN (1964) suggested that a bacterial diet was responsible for the large number of empty digestive tracts reported by POOLE (1959). A periodic renewal of the midgut epithelium was reported several years ago by SOMMER (1885), DENIS (1949) and PACLT (1956) in several Collembola. This feature is characteristic of all Collembola and THIBAUD (1968,1976) clearly showed that in Hypoastrurids the empty gut was associated with both the early (Fasting period I) and late (Fasting period II) intermoult during each moult cycle. DE WITH & JOOSSE (1971) obtained similar results with five species of Entomobryidae. In the present study, among the animals with empty gut (Table 2, col. 6) 6% in *M.duodecemoculata*, 23% in *A. tetracantha* and 35% in *C. decemoculata* showed signs of moulting confirmed by the presence of double cuticle. These animals were actually in the latter half of the second fasting period immediately preceding the moult. A small percentage of animals (Table 2, col. 4) with gut contents were also in the second half of the second fasting period. The gut contents in these animals did not indicate active feeding but only failure to expell the contents before the onset of the degeneration of the midgut epithelium. The comparatively low number of individuals with distinct moult sign (Table 2, col. 8) was perhaps due to the incomplete extraction in the Tullgren funnels, the success of the extraction being dependent on the mobility of animals. DE WITH & JOOSSE (1971) already showed that the mobility of animals decreased during ecdysis and increased considerably after moulting. THIBAUD (1968) found that under laboratory conditions 60% of the Hypogastrurids at a time were found to be in the nonfeeding phase and in *Tomocerus* under field conditions nearly 66% had no gut contents (KNIGHT & ANGEL, 1967). The Col-

TABLE 2. Feeding and moulting stages in the individuals of Collembola collected from an abandoned field.

Name of species	Number examined	Number of individuals with					
		gut full	gut full & moult sign	empty gut	empty gut & moult sign	empty gut, no moult sign	moulting sign
A. teracantha	110	67 61%	7 10%	43 39%	10 23%	33 77%	17 15%
C. decemoculata	44	18 41%	3 16%	26 59%	9 35%	17 65%	12 27%
M. duodecemoculata	44	8 18%	1 13%	36 82%	2 6%	34 94%	3 7%



Figs. 2 & 3. Photomicrographs showing the gut contents of *Microparomella duodecemoculata* PRABHOO. X Unidentified spore; EP Spore of *Epicoccum*. Figs. 4 & 5. Photomicrographs showing the gut contents of *Cyphoderopsis duodecemoculata* PRABHOO. AS Amorphous substance; CO Spores of *Cordana*; Cu Spores of *Curvularia*; Y Unidentified spores.

lembola on an average were thought to feed only during 50% of their adult life (ANDERSON & HEALEY, 1972). In the present study it was found that at any time of the year 33%—54% of the individuals in *A. tetracantha*, 50%—89% of the individuals of *M. duodecemoculata* and 33%—70% of *C. decemoculata* under field conditions were in the nonfeeeding stage. Maintenance of normal growth and activity in these animals in spite of their relatively low feeding rate would be possible only if they showed a high degree of assimilation of nutrients from food as observed by HEALEY (1967) in *Onychiurus procampatus*.

Acknowledgements :—We are thankful to Dr. T.A. ABRAHAM, Department of Botany, University of Kerala for the identification of the fungal materials and Prof. K.M. ALEXANDER for facilities in the Department. N.R.P. is also thankful to the U.G.C. for financial assistance.

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Entomon, 1978, *Vol.* 3, *No.* 2, *pp.* 215 *to* 219

REVISION OF THE GENUS *PAGYDA* WALKER FOR THE REVALIDATION OF ITS SYNONYM *SYNCLERA* LEDERER ALONG WITH THE DESCRIPTION OF A NEW SPECIES (LEPIDOPTERA : PYRALIDOIDEA : PYRAUSTIDAE)[1]

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Genus *Synclera* Lederer, so far considered as a synonym of genus *Pagyda* Walker, has been disengaged from *Pagyda* on the basis of the differences in the structure of the genitalia and the labial palpi for its reuse as a valid generic name. A new species, *Synclera himachalensis*, (Zeller) has been described and compared with *S. straducalis* (Zeller) and *P. salvalis* Walker, the type species of *Synclera* and *Pagyda* respectively. A key to the species *Synclera* is also given.

(Key words : **Revision, *Pagyda*, revalidation, synonym, *Synclara* Lederer, new species)**

Of the ten species described by Hampson (1896, 1898) in genus *Pagyda* Walker, only two species viz., *salvalis* Walker and *traducalis* Zeller were from North-West India. The authors also collected the above mentioned two species and a third one representing a new species. A detailed examination of these three species shows that only one species is actually referable to the genus *Pagyda* whereas the remaining two allied species differ from the former in several respects and are not congeneric with it. As one of these two species (*traducalis* Zeller) is the type species of Genus *Synclera* Lederer, consisdered as synonym of *Pagyda* by Hampson (1896, 1898) and Klima (1939), both the species are accordingly assigned to *Synclera* which has been brought into reuse. A complete characterization of the genus *Synclera* along with a detailed description of *S. himachalensis*, sp. nov., is recorded below.

The genus *Synclera* was erected by Lederer on the type species *Eudioptis traducalis* Zeller. Hampson (1896, 1898) and Klima (1939), however, treated *Synclera* Lederer as a synonym of *Pagyda* Walker. A comparison of the type species of the two genera in our possession shows that they have significant differences in the structure of their genitalia and the labial palpi. In fact, the non-porrect nature of the third segment of the labial palpus takes genus *Synclera* to a group genera different from the other group including *Pagyda* where the third segment of the labial palpus is porrect. In the circumstances, *Synclera* becomes available as a valid generic name and is removed from the synonymies of *Pagyda*. Although some workers have already used the generic name *Synclera* for its type species in their recent publications (Nazmi, 1963 ; Amsel, 1970 ; Sauter, 1973) but the complete characterization of the genus including the details of the male and the female genitalia, as given below, has been accomplished by the authors. In addition to *S. traducalis* (Zeller) and

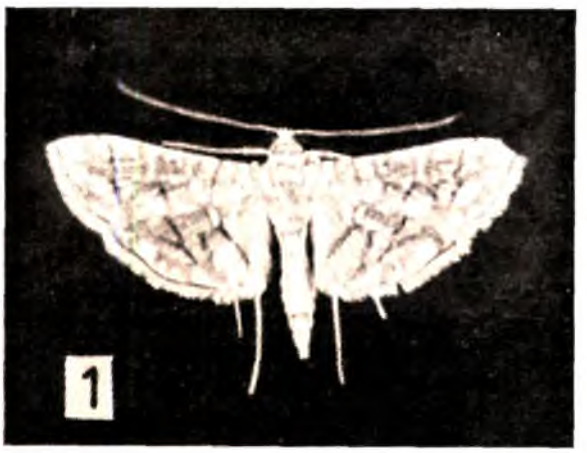
[1] From Ph.D. thesis of the second author, approved for the doctorate degree by the Punjab University, Chandigarh.

himachalensis sp. nov. described below the two species viz. *subtessellalis* Walker, *stramineallis* Hampson described by Hampson (1896) under *Pagyda* (*Synclera* group) might also be ultimately shifted to *Synclera* after the study of their genitalia and other characters

Genus : *Synclera* Lederer *Wien. Ent. Monatschr.* 7, p. 444 (1896).

Type-species : *Eudioptis traducalis* Zeller *Kgl. Vet. Akad. Handl. Lep. Micropt. Caffr.* p. 54 (1852).

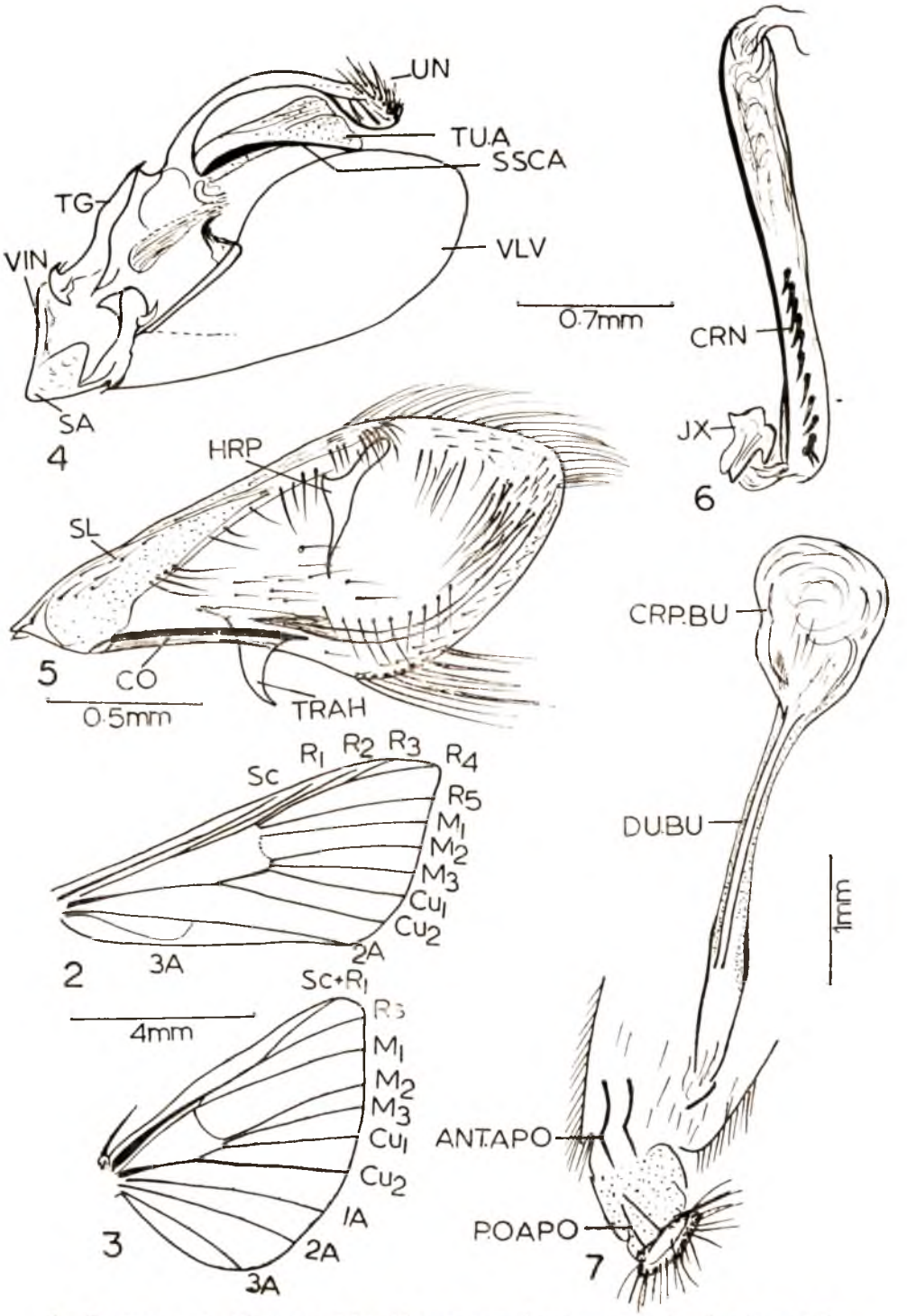
Labial palpus vertically upturned ; second segment broadly scaled ; third segment with the tuft of scales long and extending beyond the tuft of second joint. Maxillary palpus filiform. Frons rounded. Antenna with flagellum completely annulated. Forewing with the cell longer than half the length of wing ; R2 closely approximateled to R3 + 4; R5 straight, well separated from R3+4 ; M2 and M3 and Cul from lower angle of cell. Hindwing with Rs anastomosing with Sc+R1; M2 and M3 closely approximated at origin for some distance; Cul from lower angle of cell. Mesothoracic leg with outer spur on tibia of two-thirds length of inner; outer spur of anterior pair on hindtibia one-third length of inner. Male genitalia with the uncus long and spatulate at distal end ; tuba analis with subscaphium present ; valva with a harpe; each half of transtilla more or less triangular in shape. Female genitalia with corpus bursae without signum.



Figs. 1-7. *Synclera himachalensis* new species : 1. photograph of the adult.

ABBREVIATIONS USED

1A—first anal vein ; 2A—second anal vein ; 3A—third anal vein ; ANT. APO—anterior apophyses ; CO—costa ; CRN—cornuti ; CRP. BU—corpus bursae ; Cul—first cubital vein ; Cu2—second cubital vein ; DU. BU—ductus bursae ; HRP—harpe ; JX—juxta; M1—first median vein ; M2—second median vein ; M3—third median vein ; PO. APO—posterior apophyses; R1—first radialvein ; R2—second radial vein; R3—third radial vein ;R4—fourth radial vein ; R5—fifth radidal vein ; Ts—radial sector ; SA—saccus ; Sc—subcosta ; Sc—R1—stalk of Sc and R1 ; SL—sacculus ; SSCA—subscaphium ; TG.—tegumen ; TRAH—half transtilla ; TU. A.—tuba analis ; UN—uncus ; VIN—vinculum ; VLV—vulva.



2. Forewing ; 3 Hindwing ; 4,5,6. different parts of male genitalia ; 7. female genitalia.

Synclera himachalensis sp. nov. (Figs. 1,7)

Head : Vertex furnished with white scales; frons rounded, covered with pale scales, scales along inner sides of eyes white. Antenna slightly longer than forewing ; scape white anteriorly and yellow posteriorly; flagellum completely annulated with fulvous scales. Eye brownish black, with a row of white scales behind. Ocellus well developed. Labial palpus vertically upturned ; all segments covered with white scales ; first and second segments with greyish scales on lateral surfaces; the tuft of scales on third segment pointed and extending beyond the fringe of second joint. Maxillary palpus filiform, covered with white scales. Proboscis long, with white scales basally. Posterior margin of head studded with long and erect white scales, tinged with pale scales.

Thorax covered with ferrugino-testaceous scales, irrorated with white scales dorsally ; pure white ventrally.

Fore wing : Costal margin strongly arched toward apex ; apex produced and acute; termen oblique, somewhat curved in middle; tornus obtusely angulate ; anal margin weakly incurved towards outer angle. Ground colour white, marked with ferrugino-testaceous markings or bands ; a basal line with a broad subbasel line carrying a few white spots ; an outwardly running oblique antemedial line from costa to inner margin ; a broad medial band containing two white spots ; a discocellular line from anterior margin to posterior margin, sharply diverging at lower angle of cell, followed by a fine streak behind cell and a broad white patch beyond diverged portion ; a slightly broad postmedial band from costa to posterior margin; outer marginal area broad, with its inner margin angulate at vein M2 and joined to the postmedial line near tornus, with a few white patches and spots ; margin fusco-ferrugineous ; marginal fringe shining brownish grey. Discal cell more than half the length of wing. Sc straight and extend along cell length ; R1 from middle of cell; R2 from anterior angle of cell, approximated to R3+4; M1 arising far from R5; M2, M3 and Cu1 from posterior angle of cell, equidistant at base and strongly diverging; Cu1 at three-fourths length of cell; 3 A making loop with 2A at base.

Hindwing : Costal margin nearly striaght; apex rounded; termen and tornus rounded. Ground colour white, irrorated with ferrugino-testaceous scales and lines: a medial band extending upto inner margin and carrying a white patch at the distal end of cell ; an irregular postmedial line extending from base of Cu1 to near tornus, much wider between Cu_2 and posterior end; outer marginal area broad and ferrugino-testaceous, with its inner margin joining postmedial line at Cu2, three oblong white patches immediately beneath inner margin, two white obscure spots near apex and four white specks near termen ; marginal fringe brownish grey. Discal cell about one-third the length of cell ; cell closed. M2 and M3 approximated at base for some distance and strongly diverging distally ; Cu1 radiating from posterior angle of cell ; Cu2 from well before lower angle of cell ; three anals present.

Leg clothed with white scales ; prothoracic leg with femur covered with shining brown scales on outer side, its tibia covered with fuscous scaling ; meso- and meta-tibia with a few fuscous scales at their extremities; outer spur of midtibia two-thirds length of inner ; outer spur of anterior pair on hindtibia one-third as long as inner and that of posterior pair more than half and less than two-thirds length of inner.

Abdomen dark yellowish brown dorsally and with white patches ; white ventrally and with ochreous tinge ; anal tuft composed of black and white scales in male.

Male genitalia : Uncus long, curved, broad at base, narrow in middle, strongly spatulate at distal end, its dorso-distal surface densely setose with short and strong setae ; gnathos absent ; tuba analis shorter than uncus ; scaphium not developed ; subscaphium represented by a sclerotized strap ; tegumen slightly longer than broad and well sclerotized ; vinculum V-shaped; saccus reduced. Valva long, narrow at base, broad in middle, tapering and rounded at distal end ; costa broadly inflated, with a prominent sclerotized bar ; sacculus differentiated, with a few setae on its inner margin ; harpe long and strongly sclerotized, pointed at costal end, more or less nipple-like at saccular end. Transtilla weakly sclerotized, with each half roughly triangular in shape; juxta irregular in out line. Aedeagus long and slender, with one wall better sclerotized than the other; vesica impregnated with eleven cornuti.

Female genitalia : Corpus bursae with anterior half rounded and membranous, followed by a constriction in the middle, basal half somewhat sclerotized ; signum absent; ductus bursae long and moderately broad ; genital plate missing ; anterior apophyses long, stout and slightly bent below middle ; posterior apophyses shorter than anterior apophyses and weakly sclerotized ; ovipositor lobes broad, each bearing long and short setae.

Alar expanse : male 20 mm to 21·5mm Female 19 mm.

Holotype ♂, **Allotype** ♂, **Paratypes** 3♂♂, 2 ♀♀, INDIA: HIMACHAL PRADESH :Solan, night collection from light, H.S. Rose, 24. ix. 1973. Material in Entomology Section, Department of Zoology, Panjab University, Chandigarh.

KEY TO THE SPECIES OF GENUS SYNCLERA LEDERER

Antennae shorter than the forewings ; wings semihyaline white and marked with fulvous yellow markings ; aedeagus with vesica armed with numerous cornuti..... *traducalis* Zeller

Antennae slightly longer than the forewings ; wings white and marked with ferrugino-testaceous markings ; aedeagus with vesica bearing eleven short cornuti..... *himachalensis* sp.nov.

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Entomon, 1978, *Vol.* 3, *No.* 2, *pp.* 221 *to* 228

A REVIEW OF *DOLICHOTHRIPS* KARNY AND *DOLICHOLEPTA* PRIESNER, WITH DESCRIPTIONS OF TWO NEW GENERA (INSECTA : THYSANOPTERA : PHLAEOTHRIPIDAE)

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The characterisation of *Dolichothrips* Karny and *Dolicholepta* Priesner, and the species included under them, is discussed. *Dolicholepta arorai* Bhatti and Hattar is transferred to a new genus *Maxillithrips*, and *Dolichothrips indicus* (Hood) is transferred to *Membrothrips*, gen.nov.

(*Key words:* **review, *Dolichothrips* Karny, *Dolicholepta* Priesner, new genera, Insecta, Thysanoptera, *Phlaeothripidae***)

Twenty-eight species have been so far included in *Dolichothrips* Karny (1912) and *Dolicholepta* Priesner (1932), all of them confined to the tropics. However in the present writer's view the placement of several of the species is not satisfactory, and the species included in these genera are in urgent need of revision in order to ascertain their correct generic assignment. Only a few of the known species are at present available to the writer, and on that basis revised generic relations have been interpreted. One species each from the two genera is hereby transferred to new genera and additional diagnostic characters are given for *Dolichothrips*. Four species placed in *Dolicholepta* by Ananthakrishnan (1970) are now treated under *Dlichothrips*. Two of these (*flaviantennatus* Seshadri & Ananthakrishnan 1954 and *inquilinus* Ananthakrishnan 1954) seem better placed in *Dolichothrips* pending their eventual definitive placement when specimens are studied. The third species, *gracilipes* Ramakrishna & Margabandhu 1939, was synonymised under *citripes* (Bagnall 1921) by Mound (1968), and the fourth species (*fulvus* Ananthakrishnan 1964) is here considered a synonym of *ochripes* Karny.

Dolicholepta Priesner.

Dolichothrips subgenus *Dolicholepta* Priesner, 1932, *Rev. Zool. Bot, Afr.*, 22 : 198. Type-species *Dolichothrips giraffa* Karny, 1920, *Anz. Akad. Wiss. Wien.* 57 : 28 [= *Liothrips micrurus* Bagnall, 1914, *Ann. Mag. Nat. Hist.*, (8) 13 : 292–293] by original designation; 1965, *Publ. Inst., Desert Egypte* (1960), 13 : 417.

Dolicholepta : Priesner, 1964, *Bestimmungsbücher zur Bodenfauna Europas*, 2 : 176 (recharacterisation) ; Mound. 1968, *Bull. Brit. Mus. (Nat. Hist). Ent., Suppl.*, 11 :86 (characters, key).

When Priesner described *Dolicholepta* in 1932, he also included *jeanneli* Bagnall, *karnyi* Faure and *varipes* Bagnall, in addition to the type-species *giraffa* Karny, characterising the new subgenus with slender legs with the fore pair not incrassate. Priesner (1935 : 363) recognised that *micrurus* and *giraffa* were conspecific. In 1964 he elevated *Dolicho-*

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lepta to the rank of a genus recognisable by a slender body, slender legs, antennal III slender and much longer than IV, antennals IV to VI produced at apex, fore-ocellus placed on a hump, forewing constricted at middle and accessory fringe hair absent on forewing. Mound (1968) separated the genus from *Dolichothrips* by lack of accessory fringe hair on forewing, elongate antennal III, forwardly extended inner apical margin of antennal segments IV to VI, and closely [longitudinally] striate metanotal sculpture. Mound included 4 species in the genus : *jeanneli*, *micrura*, *nigripes*(Bagnall) (transferred from *Dlichothrips*) and *scotti*(Morison) (transferred from *Macrophthalmothrips*), and recognised *karnyi* as a junior synonym of *jeanneli*. Mound characterised *Dolicholepta* also by having two small sense cones on antennal III (he confirms this for the types of *micrura* in his letter of 20. xi. 1974). However according to Priesner (1965) the type-species *micrura* has only one sense cone on antennal III, and *varipes* included in *Dolichothrips* has only 2 sense cones. Mound (personal communication, 20. xi. 1974) also states that at least some of the syntypes of *varipes* have 3 sense cones on antennal III.

Ananthakrishnan (1970 : 137) included 4 Indian species in *Dolicholepta* treated as a subgenus : *flaviantennatus* Sesh. & Anan., *fulvus* Anan., *gracilipes* Ram. & Marg., and *inquilinus* Anan. Of these species, *gracilipes* is recognised as a synonym of *Dolichothrips citripes* (Bagnall) (Mound, 1968 : 88), and *fulvus* is here regarded as a synonym of *Dolichothrips ochripes* Karny. Both species have maxillary bridge and metanotal sculpture different from *Dolicholepta*. The two other species are not known to the present writer. However all four of these species have about six accessory fringe on the forewing.

The strict interpretation following Mound (1968) would permit the placement of the following species in this genus : *jeanneli* (Bagnall 1921) (=*karnyi* Faure 1925, vide Mound 1968) known from Kenya, Uganda, Tanzania and South Africa ; *micrura* (Bagnall 1914) (= *giraffa* Karny 1920) from Egypt, Sudan, Morokko and Seychelles Islands ; *nigripes* (Bagnall 1936) from Ethiopia ; *proximes* (Priesner 1965) fom Egypt; *scotti* (Morison 1958) from Ethiopia. The maxillary bridge is absent in all of these as far as known, but the condition in *nigripes* and *proximus* is not known. The maxillary palps in *Dolicholepta* as well as in *Dolichothrips* are 2–segmented.

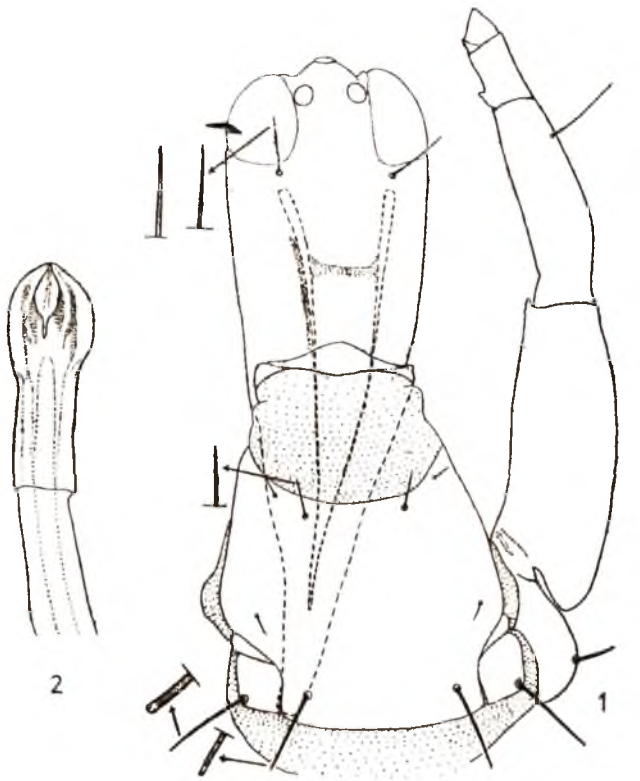
Dolicholepta gutierrezi Bournier (1969: 617–621) from Madagascar possesses 8–12 accessory hair on forewing, but lacks maxillary bridge (teste Mound, *in litt.*) as in other species of *Dolicholepta*. The condition of the metanotal striations is not known. However other features like the slender antennal III and apically produced antennals IV to VI are similar to *Dolicholepta*. The placement of *Dolichothrips* (*Dolicholepta*) *ghesquierei* Priesner (1937: 175–177) from Zaire must await study of specimens. This species has 9–13 accessory fringe hair on forewing, and metanotum with close longitudinal striations.

Dolicholepta arorai Bhatti & Hattar (1974) is here transferred to *Maxillithrips* (q. v.).

Dolichothrips Karny

Dolichothrips Karny, 1912, *Zool. Anz.*, 40 : 299. Type-species *Dolichothrips longicollis* Karny, *l. c.*, p. 299, by monotypy; Priesner, 1965, *Publ. Ins. Desert Egypte* (1960), 13 ; 417 (In Part); Mound, 1968, *Bull. Brit. Mus. (Nat. Hist.) Ent. Suppl.*, 11 : 87–88 (characters key to species).

Mound (1968) additionally characterised *Dolichothrips* and gave a key to 7 species represented in the British Museum. However the presence or absence of maxillary bridge is not described. This structure is



Figs. 1–2. *Dolichothrips longicollis* Karny : 1—Head and prothorax, dorsal, ♀ (sculpture and most of the minor setae omitted) ; 2—Pseudovirga.

present in the type-species *longicollis* (Fig. 1) and two other species before me (*citripes*, *ochripes*). Mound distinguished *Dolichothrips* by the presence of accessory fringe hair on forewing, the stout antennal III with 3 sense cones, the non-extended inner apical margins of antennals IV to VI, and the metanotal sculpture not closely striate. The number of sense cones on antennal III however varies in the species now included in this genus; *varipes* has 2 to 3 sense cones, *flaviantennatus* has 2 sense cones. But this character is not known in many species included in this genus. The basantral plates are present and the mesopresternum is degenerate in middle (Fig. 3).

Priesner (1935) transferred *citripes* (Bagnall), *flavipes* (Moulton), *indicus* (Hood) and *macrangai* (Moulton) from *Neoheegeria*. Mound (1968) transferred *fumipennis* (Bagnall) and *zizyphi* (Bagnall) from *Neoheegeria*, and distinguished *Dolichothrips* from *Neoheegeria* by the presence of 3 or more pairs of setae laterad of anterior sigmoid setae and the modification of some of these additional setae into sigmoid form. However, *indicus* seen by the present writer has no additional sigmoid setae and has the male genitalia very different from species assignable to *Dolichothrips*, and is therefore transferred to the new genus *Membrothrips* (q.v.). It appears that several other species at present assigned to *Dolichothrips*, but not available for the present study will have to be transferred to that genus. At least two unnamed species in my collection belong therein, but these may be conspecific with some of the

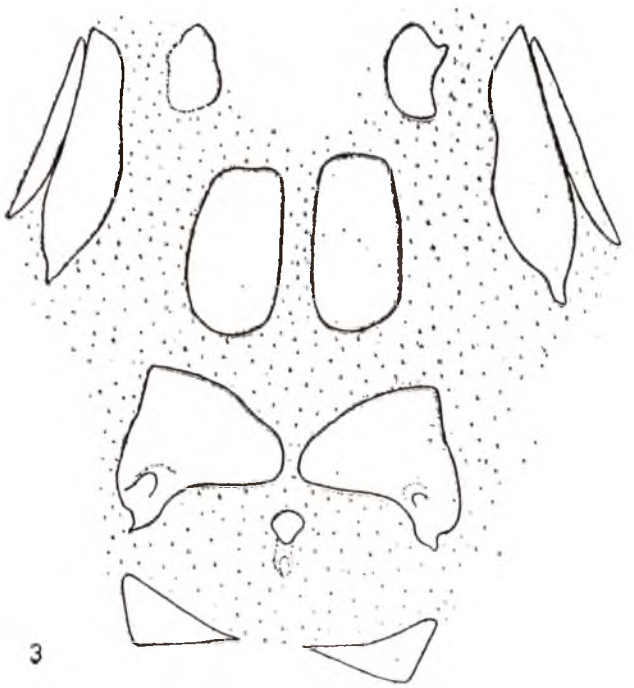


Fig. 3. *Dolichothrips longicollis* Karny : Prosternum and mesopresternum, ♀ (chaetotaxy omitted).

described species which cannot be satisfactorily recognised from their published accounts. *Membrothrips* however is not closely related to *Neoheegeria* as pointed out under that genus.

Three species, whose specimens have been studied, are at present referable to this genus: *citripes* (Bagnall 1921) (=*gracilipes* Ramakrishna & Margabandhu 1939) from India (widely distributed; *longicollis* Karny 1912 from Indonesia (Java); *ochripes* Karny 1926 (=*fulvus* Ananthakrishnan 1964) from India (Tamil Nadu, Andhra Pradesh). Several of the following 13 species also included in this genus might actually belong elsewhere: *assimilis* Priesner & Seshadri 1952 from South India (Tamil Nadu); *confusus* Ananthakrishnan 1968 from South India (Adichannalur); *flviantennatus* Seshadri & Ananthakrishnan 1954 from South India (Tamil Nadu); *flavipes* (Moulton 1928) from China (Taiwan); *fumipennis* (Bagnall 1921) from North India (Kurseong) ; *inquilinus* Ananthakrishnan 1954 from South India (Tamil Nadu) ; *macarangai* (Moulton 1928) from China (Taiwan); *malhavii* Ananthakrishnan 1961 from India (Uttar Pradesh); *montanus* Ananthakrishnan 1964 from South India (Tamil Nadu) ; *nesius* Stannard 1961 from Guam and Sri Lanka ; *pumilus* Priesner 1935 from China (Taiwan) ; *varipes* Bagnall 1921 from South India (Tamil Nadu, Karnataka) ; *zizyphi* (Bagnall 1923) from India (West Bengal). There is urgent need for a revision of the species as most of them need satisfactory definition and definitive placement.

Dolichothrips (*Dolicholepta*) *gutierrezi* Bournier 1969 from Madagascar and *Dolichothrips (Dolicholepta) ghesqierei* Priesner 1937 from Zaire cannot be satisfactorily placed until specimens are

studied, as discussed under *Dolicholepta*. Mound (1968) indicated that *D. citricruris* Moulton 1949 does not belong in *Dolichothrips* but did not indicate its placement.

Dolichothrips ochripes Karny

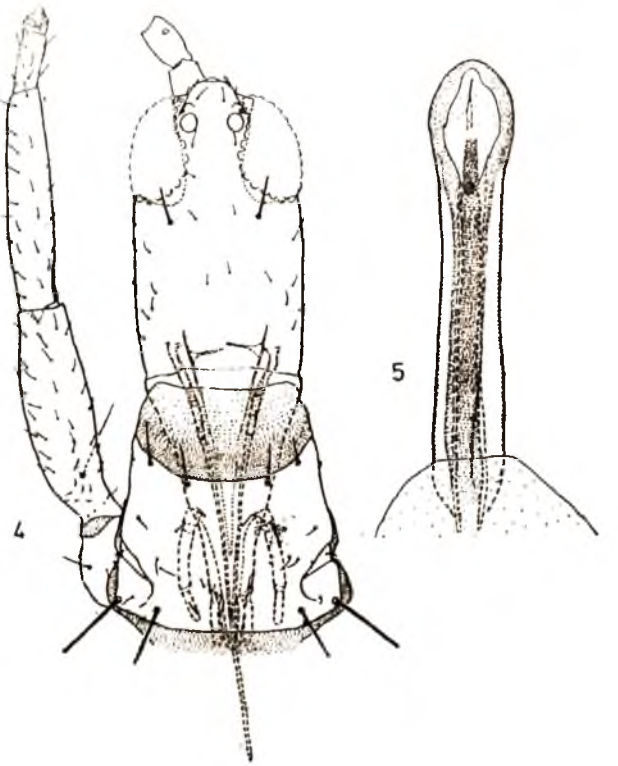
Dolichothrips ochripes Karny, 1926, *Ent. Mem. Dept. Agr. India*, 9(6) : 213–215, figs. 15a, b. Syntypes (sex not stated), INDIA : Coimbatore, TAMIL NADU : Mound, 1968, *Bull. Brit. Mus. (Nat. Hist.) Ent. Suppl.*, 11 : 88 (Key).

Dolichothrips (*Dolicholepta*) *fulvus* Ananthakrishnan, 1964, *Ent. Tidskr.*, 85 (3–4) : 223–224. ♀ ♂. Syntypes ♀ ♂, INDIA: ANDHRA PRADESH : Kona forest, near Tirupathi, New synonymy.

This species has close longitudinal striae on metanotum, but not in the same way as in *Dolicholepta* or *Maxillithrips*, since the sculpture in the mid line is longitudinally reticulate and the lines on sides are wider apart. The maxillary bridge is distinctly present.

The species is at once recognisable by the uniformly yellow legs. The pronotum is transversely striate. The notopleural sutures are incomplete. The metanotal setae at middle are not expanded at apex as stated by Mound, but taper to a fine point, although in a specimen with both setae broken at middle they look somewhat expanded ! The antennal III bears 3 sense cones and IV has 4 sense cones. The antennal segments IV to VI are weakly produced ventromesially at apex.

The above synonymy is borne out by the study of a syntype of *fulvus* and material



Figs. 4–5. *Maxillithrips arorai* (Bhatti & Hattar) : 4—Head and prothorax, dorsal, ♀ (scultpure omitted) ; 5—Pseudovirga.

from Coimbatore. The species is known from Tamil Nadu (Coimbatore) and Andhra Pradesh (Guntur, Kona).

Maxillithrips, gen. nov.

Head (Fig. 4) longer than wide, 1.7–2.0 times as long as wide; cheeks parallel-sided, not bulged. Ocellar area raised in front. Postocular setae well developed. Dorsum of head with fine, closely set transverse striae, ocellar area reticulate. Mouth cone long, sharply conical, nearly pointed apically. Maxillary stylets normal, not retracted far into the head. Maxillary bridge present. Maxillary palps 3-segmented.

Antennae 8-segmented. Segments IV to VI produced ventromesially at apex. Segment III slender, more than thrice as long as wide, with one sense cone, IV with 4 sense cones ; VIII broadly joined to VII.

Thorax : Prothorax with incomplete notopleural sutures ; all major setae well developed, dilated apically; midlaterals vestigeal, undeveloped. Pronotal surface with fine closely placed transverse striae. Basantral plates present, elongate anterioposteriorly. Mesopresternum degenerate at middle. Mesonotal surface with fine closely placed transverse striae; metanotum with fine closely placed longitudinal striae. Forewing constricted just beyond middle ; without accessory fringe hair. Legs slender ; foretarsus unarmed in both sexes.

Abdomen : Pelta triangular. Terga II to VII each with 2 pairs of large sigmoid setae, and in addition with 1 to 2 pairs of accessory sigmoid setae on each of these terga laterad of the anterior large sigmoid seta. Tube short, about half as long as head ; anal setae shorter than tube. Pseudovirga sclerotised (Fig. 5).

Type-species : **Dolicholepta arorai** Bhatti & Hattar, 1974, *Oriental Ins.* 8(4) : 551–555.

The new genus is separable from all described Tubulifera by the 3-segmented maxillary palps. As far as known to the writer, all other Tubulifera have 2-segmented maxillary palps. *Maxillithrips* is distinguishable from the closely related genus *Dolicholepta* also by the presence of a maxillary bridge which is lacking in *Dolicholepta.*

Membrothrips, gen. nov.

Head longer than wide ; cheeks nearly parallel-sided, not bulged. Postocular setae well developed. Dorsum of head with transverse striae. Mouth cone long, sharply conical, nearly pointed apically. Maxillary stylets normal, not retracted far into the head. Maxillary bridge present. Maxillary palps 2–segmented.

Antennae 8–segmented. Segments IV to VI not produced ventromesially at apex ; III relatively stout, with 3 sense cones, IV with 4 sense cones ; VIII broadly joined to VII.

Thorax. Prothorax with complete notopleural sutures; all major setae well developed, dilated apically. Pronotal surface nearly smooth. Basantral plates present. Mesopresternum degenerate at middle. Mesonotum with transverse anastomosing striae; metanotum with longitudinal striae, in midline forming longitudinal reticules. Forewing constricted just beyond middle ; with accessory fringe hair. Legs moderately slender ; foretarsus armed in both sexes.

Abdomen. Pelta triangular. Terga II to VII each with 2 pairs of sigmoid setae ; and with several setae laterad of the anterior sigmoid seta. Tube shorter than head ; anal setae longer than tube. Phallus with membranous pseudovirga.

Type-species : **Neoheegeria indica** Hood, 1919, *Insec. Inscit. Menstr.,* 7(3) : 96–98.

Dolichothrips, with *longicollis* Karny as the type-species, wherein *indicus* has been so far placed, possesses more than 2 pairs of sigmoid setae on intermediate abdominal terga. *Membrothrips* differs from *Dolichothrips* not only by having only 2 pairs of sigmoid setae on abdominal terga II to VII but also by the nature of male genitalia. In *M. indicus* and two unnamed species before me the phallus does not have a chitinised pseudovirga, typically found in genera such as *Haplothrips*, *Neoheegeria*, *Dolichothrips*, *Dolicholepta* and *Maxillithrips*. Furthermore in *Neoheegeria* there are no groups of setae just next to the anterior sigmoid setae on either side on the abdominal terga. Several of the species now included in *Dolichothrips* may have to be transferred to this genus when specimens are available.

Membrothrips indicus (Hood), com. nov.

Neoheegeria indica Hood, 1919, *Insec. Inscit. Menstr.*, 7(3) : 96–98, figs. 1, 2. ♀ ♂. Syntypes ♀ ♂ INDIA: TAMIL NADU: Coimbatore. *Dolichothrips indicus :* Priesner, 1935, *Philippine J. Sci.*, 57 : 363 ; Mound, 1968, *Bull. Brit. Mus.* (*Nat. Hist.*) *Ent. Suppl.*, 11 : 88 (synonymy, key).

Dolichothrips (*Dolicholepta*) *rambhutani* Ananthakrishnan, 1960, *J. Bombay Nat. Hist. Soc.*, 57(3) : 572–573, ♀ ♂. *Syntypes* ♀ ♂ TAMIL NADU : Kallar, Nilgiris, (synonymised by Mound 1968 : 88).

The present writer has collected a series of specimens of this species from its type-locality and its type-host *Ailanthus excelsa*. The number of sense cones on antennal segment III is 3 and not 2 as stated by Hood in the original description, as is also clear from a syntype studies by me.

Acknowledgements :—The author wishes to record his gratitude to the following for making available specimens and for information on critical species: Dr. T.N. Ananthakrishnan, Calcutta ; Dr. L.A. Mound, London ; and Dr. Richard zur Strassen, Frankfrut.

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STUDIES ON SOME INDIAN THYSANOPTERA

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This article includes descriptions of three new species of Indian Thysanoptera, one each of the families Heterothripidae, Thripidae and Phlaeothripidae. Five nominal species are recognised as junior synonyms and one species is reassigned its genus. The occurrence of *Holarthrothrips* Bagnall in India is interesting. Hitherto the genus has been known from France, Italy and Greece. The new Indian species is strikingly different from the generotype *tenuicornis* Bagnall. The description of a new species of *Exothrips* Priesner brings the number of known species of this genus in India to 10. The finding of a further species of *Apterygothrips* Priesner from India is interesting particularly because it seems to be closely related to the South African species *flavus* Faure.

(Key words : **Indian Thysanoptera)**

Family HETEROTHRIPIDAE

1. Holarthrothrips indicus n. sp.

Female (macropterous) : Body dark brown. Antennal segments I and II light brown, III and IV pale yellow, V–IX dark brown. Forewings clear, without any shade. Legs pale yellow, only outer (convex) margin of femora with a slight brownish shade. All setae colourless, subhyaline. Ocellar crescents crimson.

Head with two rows of postocular setae ; interocellar setae placed between the fore- and hind-ocelli ; with two pairs of anteocellars; none of the head setae outstanding. Length[3] (and width) of antennal segments : III 62–63(21), IV 45–47 (20), V 39(16), VI 47(16), VII 39(13), VIII 31(10), IX 37(7).

Pronotum with a single strong seta at each posterior angle, 41–43 long ; posterior margin with 7–8 pairs of setae, with a broad setaless gap medially ; each anterior angle with a well developed seta. Spinula present on mesosternum, absent on metasternum. Metascutum sculptured as in *tenuicornis*. Forewing fairly broad, with costal setae at middle of wing about as long as the width of wing at middle. Costa with 31–35 setae ; upper vein with 3+15 setae running to distal fourth of wing, then a short gap followed by 3 setae till apex ; lower vein with 17–19 setae ; scale with 7–8 venal setae and 1 discal seta near base. Wing fringes straight.

Abdominal terga with dense rows of microtrichia on sides ; comb of microtrichia along posterior margin of terga I–V present on sides. Terga VII and VIII with complete comb along posterior margin. Sterna II–VI completely fringed with micro-

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[3] All measurements are in μ, unless otherwise stated.

trichia on posterior margin ; on VII interrupted medially. Tergum X not split. Total body length (distended) 1540.

Holotype 1 ♀, **Paratypes** 50 ♀ ♀ INDIA, MADHYA PRADESH, Misrod, 19. xi. 1966, *Phoenix* inflorescence, T. N. Ananthakrishnan.

Holarthrothrips indicus is distinct from the generotype and the only known species of the genus, *tenuicornis* Bagnall, by the unshaded wings and shorter posteroangular pronotal setae

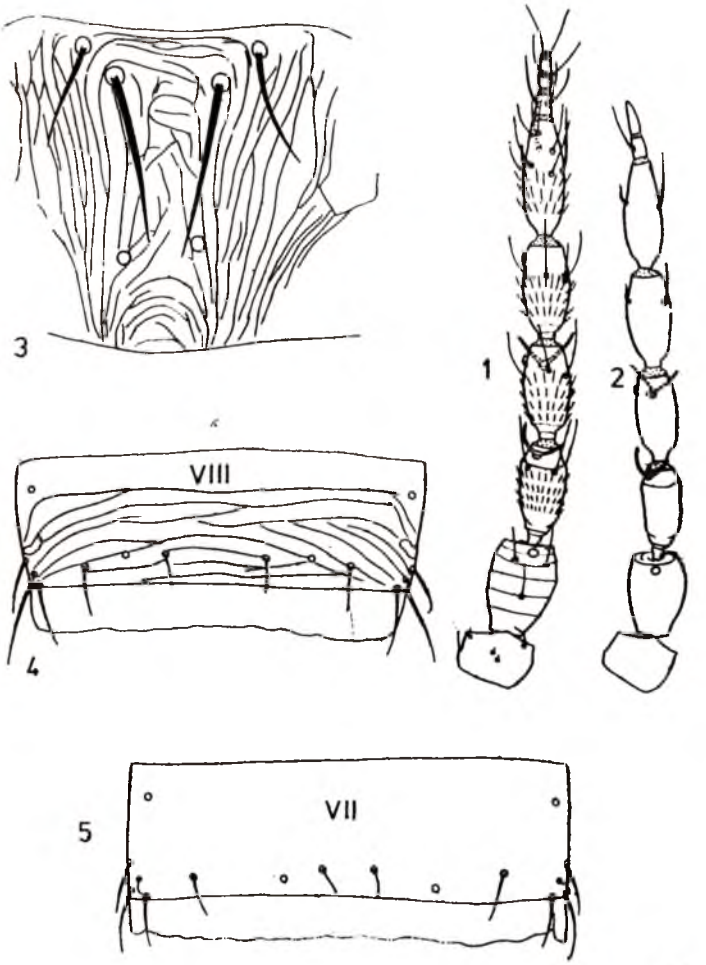
Family THRIPIDAE

2. **Chirothrips africanus** Priesner

Chirothrips africanus Priesner, 1932, *Bull. Soc. Ent. Egypte* 16 : 46–47 (♀ ♂ type-locality Giza, Egypt).

Chirothrips ramarkrishnai Ananthakrishnan, 1957, *Zool. Anz.* 159 (5–6) 95–97, 3 figs. (♀ type-locality Coimbatore, Tamil Nadu, India) New Synonymy.

The Indian material of *ramakrishnai* has been compared with syntypes of *africanus*,



Figs. 1–5. *Exothrips shweta*. 1. Antenna, dorsal, ♀. 2. Outline of antenna, ♂. 3. Part of metascutum, ♀. 4. Abdominal tergum VIII, ♂. 5. Abdominal tergum VII, ♂.

and found conspecific. The gland areas on male abdominal sterna are present only on sterna III–VI as has been found after treating syntypes from Egypt with NaOH, contrary to: the statement in literature (Priesner 1965, 235) that the gland areas are present on sterna III–VII. The oval areas on the syntypes measure 17–32 in width.

Zur Strassen (1960 : 154–155) used the length of ovipositor compared with the length of pronotum to separate *africanus* from *manicatus* the ovipositor being shorter than pronotum in the former and longer in the latter. The length of pronotum/ovipositor taken on two syntype females of *africanus* is 136/140 and 152/144 respectively. Also one brachypterous female of *manicatus* from Frankfurt (West Germany) has the pronotum actually longer than ovipositor (152/140). Thus this character is not useful for their separation.

Shumsher's record of *manicatus* from Ajmer (Rajasthan) (Shumsher, 1947 : 202) in all probability refers to *africanus* since this species has been found to be common in Rajasthan.

3. **Diarthrothrips nimbus** (Ananthakrishnan) new comb.

Mycterothrips nimbus Ananthakrishnan, 1965, *Bull. Ent.* 6 : 20 (♀ type–locality Hyderabad, Andhra Pradesh, India).

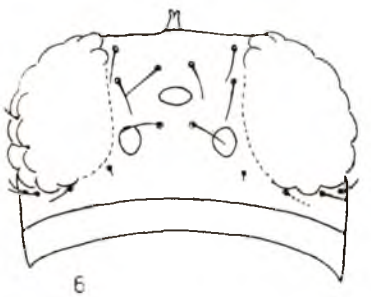
Diarthrothrips coffeae : Ananthakrishnan, 1965, *Bull. Ent.* 6 : 28 (not Williams 1915).

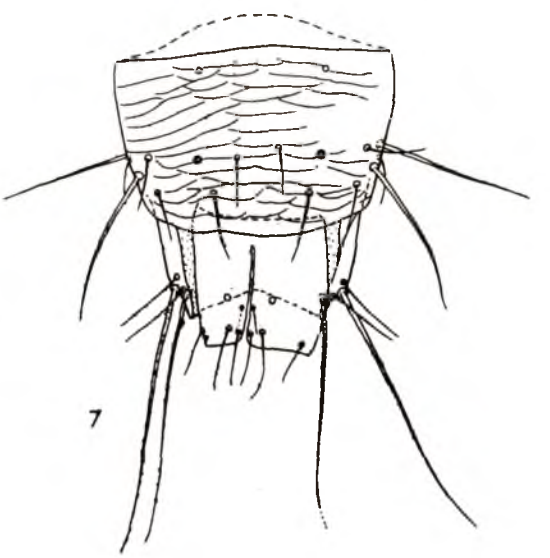
Diarthrothrips lantana Bhatti, 1967, *Thysanoptera nova Indica* p. 19 (♀ ♂ type-locality Jabalpur, Madhya Pradesh India) New synonymy.

The type material of both *nimbus* and *lantana* is identical. The Indian specimens, including those reported as *coffeae* are different from the African species *coffeae*. *Diarthrothrips* nimbus seems to be distributed widely in India.

4. **Exothrips shweta** n. sp. (Figs. 1–7)

Parexothrips tenellus : Ananthakrishnan 1968, *Zool. Anz.* 180 (3–4) 264 (not Priesner 1950).





Figs. 6–7. *Exothrips shweta* : 6. Head, dorsal, ♂ (sculpture omitted).
7. Abdominal segments IX and X, dorsal, ♂.

Female (macropterous) : Body pale whitish yellow, abdominal segment X dark brown in distal third. Antennal segments I, and III–V pale whitish ; II yellowish like body ; a little less than distal half of VI and all of VII brown ; VIII very light brown. Wings unshaded. Legs concolorous with body, unguitractor plates dark brown. Ocellar crescents red. Setae hyaline, unshaded.

Head L 83, W at eyes 108 at cheeks 101 with 3 pairs of anteocellar setae (exceptionally, as in holotype, only 2 anteocellar setae present on one side). Interocellar setae placed between hind-ocelli. Antennae 193 long, length (and width) of segments : I 19(21), II 30(20), III 32–33(13), IV 28–29 (14–15), V 30(15), VI 34–35(13), VII 7(5), VIII 12(4) .

Pronotum L 126, W 132. Mesonotum with medain pair of setae placed far forward of posterior margin ; minor sublateral seta rudimentary, indistinct. Median pair of metanotal setae placed back of anterior margin or almost at margin ; interval between these setae usually (in 15 specimens) about twice the interval between median and submedian setae of either side, in 8 specimens the two intervals about equal ; discal pores present.

Forewing L 504–512(496–), W at middle 24–25. Costal setae at middle of forewing 22–25 long, about 0.92–0.96 times the width of wing at middle. Costa with 18–19 (17–25) setae, their variability is depicted in Table 1.

Upper vein with mostly 9 setae, of which there are 3+3 basal and 3 distal setae; rarely there are 8 or 10 setae ; 44 wings have 3+3 basal and 3 distal setae, one wing each has 3+3b, 2d and 4+3b, 3d. Lower vein with 4 setae on 45 wings, 3 setae on only one wing. Scale with 5 venal setae and none discal (5+0) on 43 wings, 4+0 on 2 wings, and 5+1 on one wing. Foretibia unarmed ; forefemur W 47 ; hindtibia L 97 .

Abdominal tergum II with 4 lateral marginal setae ; seta S4 reduced on terga VI–VIII, not much shorter than S3 on tergum V. Sternum VII with median pair of setae subequal to submedian pair. Ovipositor L 226. Total body length (distended) 932.

Male (macropterous) : Colour similar to female, except these differences : terminal antennal segments and apex of abdomen not shaded.

Length (and width) of antennal segments : I 17(18), II 25(17–18), III 27(12), IV 23–26(12), V 27(12), VI 31(12), VII 7(4), VIII 10(3). Costa of forewing with 18(19) setae ; upper vein with 9 setae (3+3b, 3d) on 4 wings, 8 (3+2b, 3d) and 10 (4+2b, 4d) on one wing each; lower vein with 4 setae on 4 wings, and 3 and 5 on one wing each. Foretibia unrmed; forefemur W 43 ; hindtibia L 93.

TABLE 1. *Exothrips shweta*, variation in costal setae.

Number of setae	17	18	19	20	21	22	23	24	25
♀♀ : Number of wings									
Madurai (36)	1	7	10	9	7	2			
Aravankadu (8)				2	2	1	2		1
Papanasam (2)		1			1				
Total (=46)	1	8	10	11	10	3	2		1
♂♂ :									
Madurai (6)		2	4						

Abdominal terga with smooth postmarginal flange. Sides of abdominal sterna without patches of microtrichia. Tergum IX without especially developed median setae. Hypophallus 105 long. Total body length (distended) 900.

Holotype 1 ♀, allotype 1 ♂, paratypes, 17 ♀ ♀, and 2 ♂ ♂ INDIA, TAMIL NADU, Tirupurankundran (*ca.* 152m), Madurai hills, 16. x. 1964, grass, T. N. Ananthakrishnan ; 4 ♀ ♀ (paratypes), Aravankadu (ca. 1500m), Nilgiris, Tamil Nadu, 21. ii. 1966, *Interrupta* grass, T. N. Ananthakrishnan ; 1 ♀ (paratype), Papanasam, Tinnevelly district, 24. vii. 1965, grass, T. N. Ananthakrishnan.

Exothrips shweta is easily recognisable from all other Indian species. The combination of 3 pairs of anteocellar setae, position of interocellar setae between hindocelli, and absence of spine-like setae on male abdominal tergum IX, marks out this species from all others *Paraxothrips tennellus* Priesner, with which it was considered conspecific, differs in having only one pair of anteocellar setae, and in many other features (Bhatti 1975).

5. **Florithrips traegardhi** (Trybom)

Physapus traegardhi Trybom, 1911, *Results Swedish Zool. Exped. Egypt and White Nile* 1901, 4: 4–6, pl. I, figs. 2. 3 (♀ type-locality South of Kaka, Upper Nile, Sudan).

Taeniothrips fulvus Ananthakrishnan & Jagadish, 1969, *Zool. Anz.* 182(1–2) : 114–115, fig. 1 (♀ ♂ type-locality Thoppur ghat, Salem district, Tamil Nadu, India) New synonymy.

Florithrips traegardhi : Bhatti, 1970, *Oriental Ins.* (1969), 3(4) : 377.

Two syntype specimens of *traegardhi* from the Riksmuseum, Stockholm (made available through the courtesy of Dr. Per Inge Persson) were compared with a paratype of *fulvus* and found conspecific. *Florithrips traegardhi* is recorded in literature from several parts of India, and from Sudan and Egypt.

6. **Lefroyothrips obscurus** (Anan. & Jaga.)

Taeniothrips obscurus Ananthakrishnan & Jagadish, 1966, *Indian J. Ent.*, 28(2) : 253–255, figs. 2 (♀ ♂ type locality Valparai, Annamalai, Tamil Nadu, India.).

Taeniothrips vinnulus Ananthakrishnan & Jagadish, 1969, *Zool. Anz.*, 182(1–2) : 115 116, 117, fig. 3 (♀ type-locality Courtallum, Tinnevelly district, Tamil Nadu, India) New synonymy.

Lefroyothrips obscurus : Bhatti (In Press).

The unique holotype of *vinnulus* is similar to the holotype of *obscurus* but has both interocellar setae missing. The prominent bases of these setae are however clearly visible, thereby indicating that long interocellar setae missing. The prominent bases of these setae are however clearly visible, thereby indicating that long interocellar setae were present. In other features the two holotypes are identical. *Lefroyothrips obscurus* comes close to *fasciatus* Moulton. The two species need to be compared in order to bring out their differences.

Lefroyothrips Priesner has been considered a full genus with a number of species transferred from *Taeniothrips* (Bhatti, In Press).

7. **Sorghothrips jonnaphilus** (Ramakrishna)

Taeniothrips jonnaphila Ramakrishna, 1928, *Ent. Mem. Dept. Agr. India* 10 (6) : 256–258 (♀ type locality Coimbatore, Tamil Nadu, India).

Ramakrishnothrips jonnaphilus :Shumsher, 1942, *Indian J. Ent.* 4(2) : 117 (additional

characters); Ananthakrishnan, 1960, *J. Bombay Nat. Hist. Soc.* 57 (3): 560–561 (In Part).

Sorghothrips jonnaphilus: Bhatti, 1970, *Oriental Ins.* (1969): 3(4): 380 (♂ characters).

Ramakrishna described the species from "about a dozen females collected from tassels of maize in Guntur (No. 115), and from tender leaf shoots of jonna (*Sorghum*) in Coimbatore (No. 137), and Samalkota (No. 181). Recently also noted on sugarcane leaves, Coimbatore (V.M. Coll.) No. 181a". Ramakrishna also noted that the larva (unnamed instar) has dark distal antennal segments. All that remains of this material is one slide (Coimbatore, leaf shoots of *Sorghum* T. V. Ramakrishna Ayyar No.137) containing 3 ♀ specimens of which two are in fragmentary condition. The third specimen which has both antennae is hereby designated as the lectotype.

The male sex was reported by Bhatti (1970). The characteristic structure of the male antenna is very similar to that of the generotype *longistylus* (Trybom). The males of *jonnaphilus* reported by Ananthakrishnan (1960) belong to *Sciothrips cardamomi* (Ramakrishna). The males of *jonnaphilus* have been collected so far only once (Delhi, 89 ♀ 5♂, viii. 1967, *Sorghum* leaves, J. S. Bhatti).

8. Thrips latis Bhatti

Thrips latis Bhatti, 1967, *Thysanoptera nova Indica*, pp. 17–18 (♀ ♂ type-locality Sibpore Howrah district, West Bengal, India).

Thrips ignobilis Ananthakrishnan & Jagadish, 1969, *Zool. Anz.* 182 (1–2): 116–117, fig. 4 (♀ type-locality Adichanalur, Kerala, India) New synonymy.

This is a yellow species with banded wings. The upper vein of forewing has two distal setae.

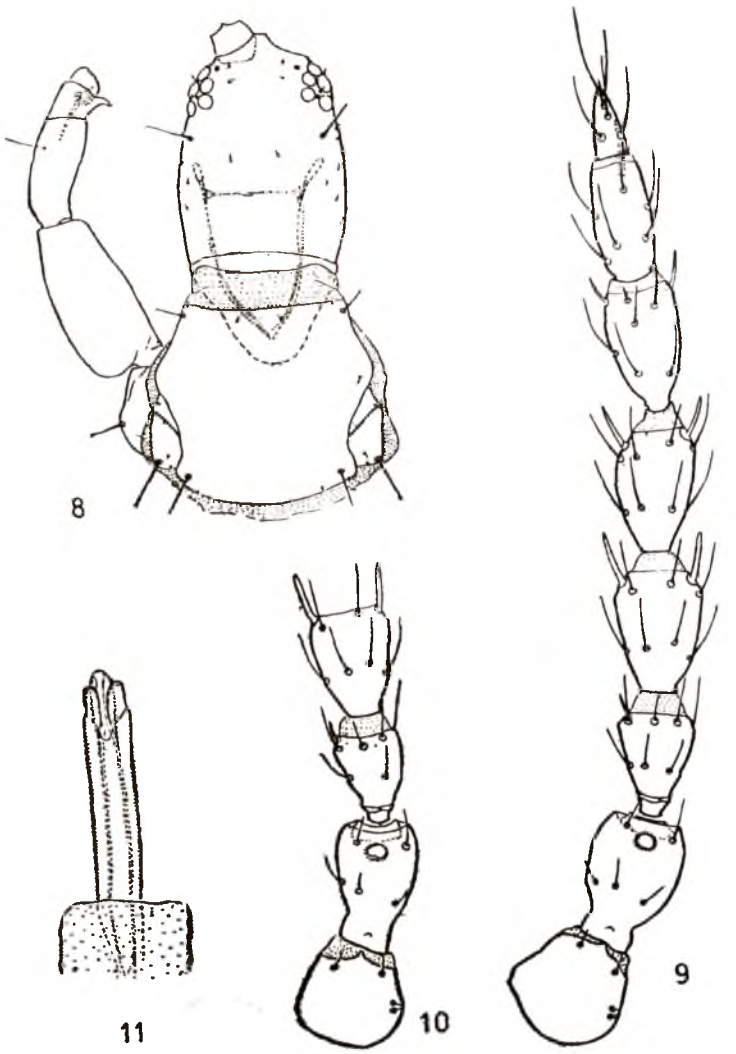
Family PHLAEOTHRIPIDAE

9. Apterygothrips dempax n. sp. (Figs. 8–11)

Apterygothrips flavus: Ananthakrishnan, 1966, *Bull. Ent.* 7: 1–2 (not Faure 1940).

Female (apterous): Body largely pale yellow, including legs; at least the tube dark brown; antennal segments I–IV concolorous with body, V light brown in distal third to half of unshaded completely; VI–VIII brown; pretarsal plates and labral cup very dark; setae hyaline, unshaded, except the major setae on segment IX which are lightly infumated, and on X darker gray brown. *In the holotype:* abdominal segments IX and X dark brown, posterior margin on sides of VIII light brown; antennal segment V light brown in distal third to one half. In an extremely *light specimen* (23. vii. 1965): the tube is dark brown only in its distal two-thirds, yellow in anterior third, the segments VIII and IX unshaded; antennal segment V pale yellow completely. In *two other females* (with similar collection data): tube completely dark brown, segment IX light brown in posterior half; antennal segment V indistinctly shaded.

Head about 1.46–1.50 times as long as wide; cheeks prominently bulging; L 173 (172), W at eyes 103, at cheeks 118(114); ocelli absent. Each eye with 8 ommatidia. Dorsum of head smooth, unsculptured. Postocular setae tapering to a fine point, about 35(35–39) long, placed 14 behind the eyes on either side. Maxillary bridge 62 (58–72) wide. Antennae 252(258) long. Sense cone formula: III 0–1 (very weak), IV 1–1, V 1–1, VI 1–1 (+1 dorsal) (major cones slender), VII 1 dorsal. L/W index of antennal segments: III 1·38–1·55, IV 1·32–1·44, V 1·50–1·59, VI 1·67–1·80. Measurements of antennal segments:



Figs. 8–11. *Apterygothrips dempax*. 8. Head and prothroax, dorsal, ♀. 9. Antenna, dorsal, ♀. 10. Part of antenna, dorsal, ♀, showing variation in shape. 11. Pseudovirga.

Segment	I	II	III	IV	V	VI	VII	VIII
Length	30–32 (32–33)	40 (38–39)	30–31 (29–32)	32–33 (33–36)	35–36 (33–35)	36 (35–38)	30–33 (32–33)	21 (21–22)
Width	32 (32–34)	24–26 (25–26)	20 (21–22)	24 (25)	23 (22)	20 (21)	16–17 (16)	9 (10)

Pronotum 142(146) long, 115(110) wide at anterior margin; greatest width of prothorax (exclusive of coxae) 162(161) pronotal surface smooth, unsculptured. Anteromarginal and midlateral setae rudimentary; others well developed; anteroangulars 19 (21–24) long, epimerals 33(32–35) long, both dilated and fringed apically; posteroangulars 30(27–32) long, pointed; coxals 25(27) long, dilated and fringed apically. Foretarsus with a narrow well developed tooth at apex within. Forefemur 55(53–55) broad; hindtibia 102–105 (105–107) long. Mesonotum with a strong apically dilated and fringed seta at each lateral angle, 16 (18–21) long; with two pairs of minute pointed setae along posterior margin, and two pairs of discal pores anteriolaterally; surface smooth. Metascutum unsculptured, smooth; with two pairs of major setae, both fine and pointed, one pair placed across middle and another along posterior margin; setae of each pair wide apart; a pair of discal pores present along anterior margin, widely separated from each other. Mesopresternum degenerate in middle. Mesosternum with a long and thin seta at each lateral angle, 30 long. Wings absent. Mesothoracic spiracle extensive, 13 (16) wide, length not measurable; metathoracic spiracle 16(16–18) long, 6(9) wide.

Abdomen slender. Spiracle on segment I 17 long; on VIII 7 long. Pelta smooth, unsculptured, its anterior margin not clearly discernible with the ordinary microscope; nearly ovoid in outline; abot 59 long, 103 wide. Major lateral setae of terga I and II (one pair each) and on III–V (2 pairs each) dilated and fringed apically; on VI and VII (2 pairs each) pointed; on VIII inner setae pointed, outer dilated and strongly fringed apically; some exceptions to this are indicated in Table2. Terga without sigmoid setae. Tergum IX 57 (55–58) long. Setae on IX and X pointed, their length on IX: S1, 95(93–102); S2, 100–103(99–116); S3, 85–90(82–78); on X: S1, 73–79(79–83); S2, 103–111(110–118); S3, 81–84(84–87). Tube 79(75) long (excluding setabearing part), 52(51–52) wide at base, 28(26) wide at apex. Fustis 20(18) long. Total body length 1760(1696) (distended).

Male (apterous): Colour as in ♀. In dark specimens the abdominal segments IX and X dark brown and posterior two-thirds of VIII brown; also antennal V completely brown, although somewhat lighter than the succeeding segments.

Head about 1·24–1·34 times as long as wide at cheeks (somewhat pressed); 138

TABLE 2. *Apterygothrips dempax*, form of lateral setae on abdominal terga.

Segment	II	III		IV		V		VI		VII		VIII	
Setae	i	i	ii	i	ii	i	ii	i	ii	i	ii	i	ii
♀	6d	5d,1b	6d	5d	6d	4d,2b	[6d	4p,2b	6p	4p,2b	6p	6p	6d
♂	8d, 1b,1p	7d 2b,1p	10d	6d 2b,2p	10d	6d 1b,1p	10d	6p 3d,1b	10p	10p	10p	9p, 1b	10d
Usual condition	d	d	d	d	d	d	d	p	p	p	p	p	p

i = inner seta b = blunt p = pointed

ii = outer seta d = dilated and fringed apically

The frequency of occurrence of a particular form of seta is indicated by the numeral affixed to the symbol.

(137–150) long, width at eyes 90(90–97) at cheeks 107(107–112). Postoculars 34 (32–36) long. Maxillary bridge 66(63–73) wide. Antennae 224(230–244) long. Length/ Width index of antennal segments : III 1·20–1·47, IV 1·26–1·45, V 1·42–1·60, VI 1·58–1·78. Measurements of antennal segments:

Segment	I	II	III	IV	V	VI	VII	VIII
Length	24 (27–29)	32 (34–36)	24 (24–28)	28 (29–32)	27 (29–32)	30 (32–33)	28 (28–32)	20 (20–21
Width	26 (28)	22 (22–23)	18 (19–20)	20 (22–23)	19 (20)	19 (18–19)	16 15–16)	10 (10)

Pronotum 107(106–122) long, 110(113–125) wide at anterior margin; greatest width of prothorax (exclusive of coxae) 146(144–161) Anteroangulars 12(14–20) long, epimerals 24(24–29) posteroangulars—(26–28) coxals 20(19–23) long. Forefemur 46(46–51) wide; hindtibia 79–83(83–95) long. Lateral seta of mesonotum 9(13–16) long. Mesothoracic spiracle 9 wide; metathoracic spiracle 12 long, 8 wide.

Spiracle on abdominal segment I 12 (13–15) long. Variation of major lateral setae as in Table2. Tergum IX 53(55) long. Length of setae on IX: S1, 67(77–86); S2, 29(28–34); S3, 87(86–105); on X: S1, 59(61–73); S2, 91(87–105); S3, 63(61–73). Tube 63(68–69) long. Total body length 1008(1012–1128) (distended).

Holotype 1 ♀ **allotype** 1 ♂ **and paratypes** 2 ♀ ♀ 1 ♂ INDIA TAMIL NADU Kalahasti, 23. vii. 1965, grass, T. N. Ananthakrishnan; 3 ♂ ♂ (paratypes) with the same data but collected on 9.ix. 1964.

The new species approaches *flavus* Faure in the body coloration, but *flavus* may be separated by postocular setae expanded at tip, posteroangular pronotal setae expanded (capitate) at apex, inner lateral seta on abdominal tergum VII capitate, both pairs of lateral setae on tergum VIII capitate, and more slender antennal segment V being 1·8 times as long as wide. The length of setae on abdominal segments IX and X also seems to be greater in *flavus* but this may be variable if larger number of specimens of *flavus* are studied. The setae on IX in *flavus* are 126–128 (♀) and 108 (♂), and in *dempax* 82–116 (♀) and 67–105 (♂) long. The anal setae in *flavus* are 128 (♀) and 104 (♂) long; their length in *dempax* is 73–118 (♀) and 59–105 (♂).

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Entomon, 1978, *Vol.* 3, *No.* 2 *pp.* 239 *to* 264

ROOT-INFESTING APHIDS (HOMOPTERA : APHIDIDAE : PEMPHIGINAE) FROM NORTH EAST INDIA

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The present paper reports 14 species of root aphids collected from north-east India. These are distributed over 7 genera belonging to subfamily Pemphiginae and of these, 7 species, viz., *Chaetogeoica graminiphaga, C. polychaeta, Geoica sikkimensis, Pemphigus vulgaris, Tetraneura kalimpongensis, T. multisetosa* and *T. sikkimensis* are being reported as new to science. Besides, the hitherto unknown alate viviparous female of *Tetraneura basui* Hille Ris Lambers has been described and descriptions of the little known species and necessary taxonomic notes have also been incorporated.

(*Key words:* **Taxonomy, root aphids, 14 species including seven new**)

Aphidological work done so far in India mostly relates to the systematics of aphids infesting aerial parts of the plants. Even though extensive studies on the taxonomy of aphids in eastern India are being carried out by this laboratory since 1968, the results have primarily revealed the aphid fauna of the aerial parts of the plants. As a part of the project on the taxonomy of aphids of eastern Himalaya one of the authors (P. K. Pal) was assigned with the surveys of aphids infesting subaerial parts of the grasses and sedges (Pal and Raychaudhuri, in press). The present paper is the outcome of this survey wherein 14 species distributed over 7 genera belonging to subfamily Pemphiginae have been dealt with. Of these species, viz., *Chaetogeoica graminiphaga, C. polychaeta, Geoica sikkimensis, Pemphigus vulgaris, Tetraneura kalimpongensis, T. multisetosa and T. sikkimensis* are being reported as new to science, the hitherto unknown alate viviparous female of *Tetraneura basui* Hille Ris Lambers has been described, descriptions of the little known species and necessary taxonomic notes have also been incorporated.

All the specimens have been collected by one of the authors (PKP) and they are deposited in the collections of the Entomology Laboratory, Department of Zoology, University of Calcutta, Calcutta.

Subfamily PEMPHIGINAE

Insects small to medium sized and mostly globular secreting powdery wax. Head without lateral frontal tubercle, smooth or with various sculpturing with or without distinct wax glands or wax pores and in apterae not entirely fused with prothorax. Antennae 3–6 segmented, in alatae almost always 6-segmented, always shorter than body; p.t. always much shorter than the base of last segment; secondary rhinaria of various shapes and sizes. Eyes in apterae with only 3 facets but in alatae multifaceted. Rostrum usually short in viviparae and sexuparae, being absent in embryos within sexuparae and in sexuals (the absence of rostrum in embryo in sexuparae is indicated by the absence of stylets that can normally be seen within the abdomen of viviparae). Thoracic and abdominal dorsum with hairs of various shapes and sizes and

with or without distinct wax plants, if present then these may be with or without hairs; siphunculi poriform or on elevated hair-bearing cone or absent; cauda short, semilunar or bluntly triangular; subanal and subgenital plates entire or sometimes these elongated in the form of a tube (sexuparae of *Prociphilus*). Legs rather short, trochanter often fused with femora, tarsi 2–segmented (one segmented in apterae of *Tetraneura*). Media in forewing simple or once branched, hindwing with 1 or 2 oblique veins. First tarsal segments with upto 3 ventral hairs, empodium hair like.

The members of this group of aphid have been recognised to be typical by their having arestrate sexuales and the embryos within the sexuparae without stylets and further that oviparous females lay single egg. However, the morphological characters as embodied in the foregone account will perhaps aid in distinguishing the members of this subfamily from those of other subfamilies.

KEY TO THE GENERA

1. Tarsi in apterae one segmented and in alatae two segmented; media in the forewing simple and hindwing with one oblique vein ..... *Tetraneura* Hartig

Tarsi in both apterae and alatae 2–segmented; media in forewing simple but hindwing with 2 oblique veins 2

2. Wax plates on abdominal dorsum compact, composed of many definite cells and bear hairs; secondary rhinaria in alate viviparae nonciliated; ultimate rostral segment without secondary hair; cauda with 2–5 hairs ..... *Pemphigus* Hartig

Wax plates on abdominal dorsum may or may not be present, if present then without hairs 3

3. Antennal segment II about 2 × segment I and about as long as segment III bearing 19-20 hairs; F.T.C. 5, 5, 4; body hairs numerous and fine; veins of the forewing dark ..... *Smynthurodes* Westwood

Antennal segment II never as long as segment III and with less numerous hairs (4–15) 4

4. At least some of the body hairs with spatulate apices and usually curved backwards; antennal segment II also with 4–8 such hairs; F.T.C. 3, 3, 3 or 3, 3, 2 ..... *Geoica* Hart

Body hairs never as above 5

5. Dorsum of head at least in apterae viviparae with reticulated pattern; antennal segment II with 4-8 hairs; wing veins bordered brown; body fine: primary rhinaria protuberant and ciliated ..... *Chaetogeoica* Remaudiere and Tao

Dorsum of head in apterae not as above; wing veins not bordered brown; wax plates, when present, not hair bearing 6

6. Antennal segment II with 7–15 hairs; primary rhinaria nonciliated; body hairs numerous and spiny: waxplates usually present on abdomen ..... *Forda* Heyden

Antennal segment II with 4–5 hairs; primary rhinaria ciliated; body hairs sparse; body with distinct wax plates ..... *Asiphonella* Theobald

Genus *Asiphonellâ* Theobald

Asiphonella Theobald, 1922. *Bull. Soc. Roy. Entomol. Egypte*, 7 : 76.

Asiphonella cynodonti (Das) (Fig. 1)

Pemphigus (?) *cynodonti* Das, 1918. *Mem-Indian Mus.*, 6(4) : 153.

13 apterous viviparous ♀♀ and 3 apterous nymphs, INDIA : WEST BENGAL : Darjeeling: Sepkhola, 11. iv.1972, from roots of unidentified grass, 3 apterous viviparous ♀♀, 10 apterous nymphs and 8 alatiod nymphs India : West Bengal : Darjeeling : Munsung, 27.iv.1972, from roots of *Cynodon dactylon;* 8 apterous viviparous ♀♀ and 1 apterous nymph, India : West Bengal : Darjeeling : Tashiding, 29.iv.1972, from roots of *Cynodon dactylon*, 2 apterous viviparous ♀♀ and 6 apterous nynph, India : West Bengal : Darjeeling Tashiding, 25. v. 1972, from roots of *Cynodon dactylon;* 35 apteous vivparous ♀♀, 20 apterous nymphs and 1 alatod nymph India : West Bengal : Darjeeling, 17.v.1972, from roots of unidentified grass; 28 apterous viviparous ♀♀ and 56 apterous nymphs, India : West Bengal : Darjeeling: Durbin, 30.v.1972, from roots and shoots of *Cynodon dactylon.*

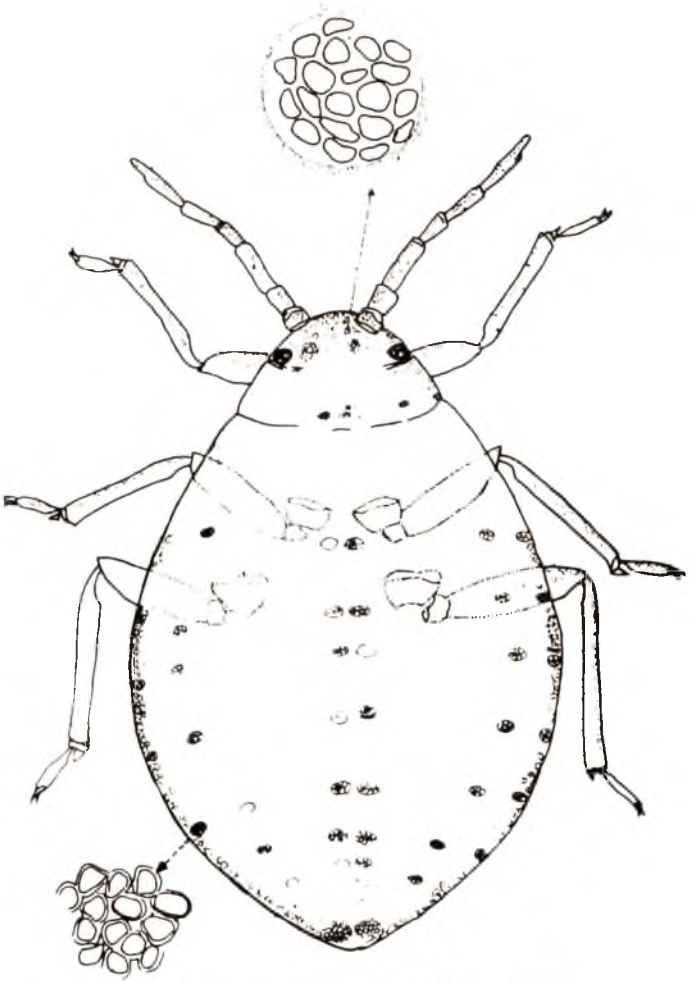

Fig. 1. *Asiphonella cynodonti* (Das) : Aptera.

Remark : From a large number of material collected in this region it could be found that there exist some variations in the morphometric ratios between different organs from those given by Das (1918) and later discussed by Remaudiere and Tao (1957). They indicated that antennae to body ratio as 0.45–0.47, processus terminalis to antennal segment III as 0.25 ; 0.36 and processus terminalis to base of last antennal segment as 0.25 : 0.41 and these in the present material are 0.33 : 0.42 ; 0.35 : 0.44 and 0.40 : 0.52 respectively. The first tarsal chaetotaxy is 3,3.3, or 3, 3, 2, which was not so far recorded by the above named workers. Inspite of these variations from original description the present material has been treated as *A. cynodonti* (Das) in view of not having access to the type material.

This is reported for the first time from India.

Distribution : India : West Bengal and Pakistan.

Genus *Chaetogeoica* Remaudiere and Tao

Chaetogeoica Ramaudiere and Tao, 1957, *Rev. Pathol. Veg. Entomol. Agr. France*, 36 : 226.

KEY TO THE SPECIES

Apterous viviparous female :

Dorsal abdominal hairs long and arranged in 6 longitudinal rows, becoming smaller caudad; marginal hairs 2–4 rarely 1; margin of abdomen with distinct wax plates . . . . . *graminiphaga*, sp. nov.

Dorsal abdominal hairs arranged irregularly all over and of more or less of equal length; marginal hairs on abdomen 3–6; marginal wax plates on abdomen absent . . . . . *polychaeta*, sp. nov.

Chaetogeoica graminiphaga, sp. nov. (Figs.2,3)

Alate viviparous female : Body pale elongated oval, about 1.45–2.30 mm long, with sparse hairs. Head brown to dark-brown, smooth, with dorsal median longitudinal suture and without lateral frontal tubercle ; dorsum of head with 8 hairs having acute apices, the longest one about 45–52 μ. Antennae coloured like the head, 6–segmented about 0.25–0.35 × the body, stout, bearing a few long and moderately stout hairs with apices similar to those on the head ; segment I about as long as segment II and bears 4 hairs, segment II with 5–6 hairs, segment III a little over 2.5 × segment II and with 12–16 hairs and the longest one 1.85–2.20 × the basal diameter of the segment ; segment IV with 3–5 hairs, segment VI slightly shorter than segment III and bears 7–12 hairs ; flagellum with spinular striae ; segments III IV, V with 16–26, 7–13, 2–5 and segment VI sometimes with 1 round to oval, small to large, ciliated and slightly protuberant secondary rhinaria ; primary rhinaria large, slightly protuberant and ciliated ; processus terminalis short and stout, about × the base of

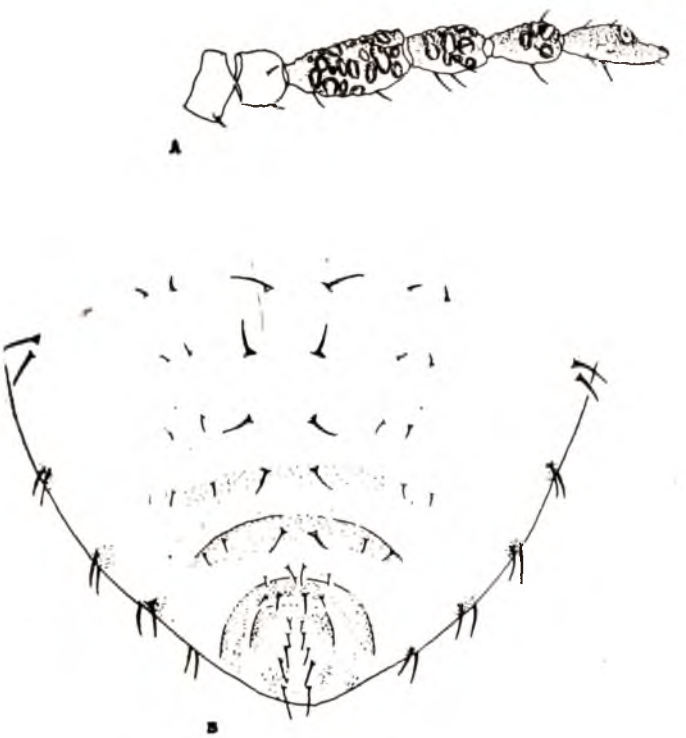

Fig. 2. *Chaetogeoica graminiphaga*, sp. nov. : Alata. A–Antenna; B–Posterior portion of abdomen.

last segment. Eyes with reduced triommatidia. Rostrum extending at most up to midcoxae ; ultimate rostral segment stout and long, about 1.25–1.38 × second segment of hindtarsus, bearing 5–7 secondary hairs, longest of these being about 57 μ. Thoracic tergite usually scabrous. Abdominal dorsum pale brown with the posterior segments comparatively darker, with indistinct segmentation upto segment 6 ; each of segments 7 and 8 with a distinct transverse brown band; dorsal hairs arising from rather darker bases, arranged in longitudinal rows, the spinal ones gradually becoming smaller caudad upto segment 7 ; usually one of the spinals and usually 2–3 rarely 1 of the marginal hairs appreciably longer than the rest ; longest dorsal hair on abdominal segments 1, 7 and 8 about 93–117μ, 56–93μ, 75–93 μ long and 4.0–5.0 ×, 2.50–4.40 × and 3.0–4.40 × the basal diameter of antennal segment III respectively ; tergite 8 usually with 8–12 hairs ; abdominal dorsum with distinct, small, round to polygonal wax gland cell groups, the marginal ones on segments 1–7 being always associated with hairs, spinopleural wax gland cells on segments 1–3 of elongate shape and those caudad polygonal. Siphunculi absent. Cauda pale brown to brown, round with 12 hairs arising from high sockets in two longitudinal median rows. Subanal plate transversely elongated or oval bearing 10–12 long hairs on high sockets. Subgenital plate large, elongated oval with 25–30 long hairs. Legs pale brown to dark brown, long with a few spinules and with hairs similar in those on the antennae ; trochanter distinct from femur ; both dorsoapical and empodial hairs on hindtarsi short with subacute apices, these about 0.55–0.75 × and 0.45–0.50 × the claw respectively ; first tarsal segments with 6,7,7 or 7,7,7 hairs. Forewings pale with costa and subcosta bordered black and subcosta with hairs on the inner margin, media simple and arising from the middle of the wing ; hindwings with 2 oblique veins.

Fig. 1 *Chaetogeoica graminiphaga*, sp. nov. : Aptera

Measurements of the holotype in mm : Length of body 2.63, width 1.50 ; antennal segments I : II : III : IV : V : VI : 0.07 : 0.07 : 0.18 : 0.11 : 0.10 : (0.11+0.05) ; ultimate rostral segment 0.21 ; second segment of hindtarsus 0.16.

Apterous viviparous female : Body globular. Head usually with reticulated pattern and bears 6 dorsal hairs which are about 55–65μ long with variable apices. Antennae 5–segmented, about 0.10–0.27 × the body, sometimes segment III with ill–developed suture indicating further segmentation ; flagellum sparsely spinulose basally densely so apicad; secondary rhinaria absent; segments I, II and IV nearly subequal and about 0.65 × segment III ; segment III about 0.67–1.03 × segment V ; segment I with 3–5, segment

II with 4–7, segment III with 3–5 hairs and the longest one segmented III being about 1.30-2.60 × the basal diameter of the segment, segment IV with 3–4 hairs ; processus terminalis about 0.27–0.48 × the base of last antennal segment. Eyes 3-faceted. Rostrum atmost reaching midcoxae ; ultimate rostral segment stout and long, about 1.64–2.10 × second segment of hindtarsus, with 2–5 secondary hairs. Reticulation on thoracic segments variably developed and wax plates on these segments also variably developed and irregularly arranged ; midthoracic furca with separate arms. Abdomen pale to pale brown, abdominal tergite 7 with 3–7 hairs spinopleurally ; tergite 8 with 3–12 hairs ; longest hair on tergites 1, 7 and 8 about 2.0–7.15 ×, 1.25–3.30 × and 1.35–3.35 × the basal diameter of antennal segment III respectively; abdominal reticulation variably developed ; wax-plates also variably developed, usually arranged on the margin of abdominal segments 1–7. Siphunculi absent. Subanal plate pale, impushed medially forming apparently two lobes, each of these with 7–10 hairs. Subgenital plate not discernible. Legs pale brown to brown, sparsely covered with hairs; first tarsal segments with 3,2,2 hairs. Other characters as in alate viviparous female.

Measurements of one specimen in mm : Length of body 1.86, width 1.53 ; antennal segments I : II : III : IV : V 0.05 : 0.06 : 0.11 : 0.06 : (0.08+0.03) ; ultimate rostral segment 0.21 ; second segment of hindtarsus 0.10.

Holotype : Alate viviparous ♀, INDIA : WEST BENGAL : Darjeeling ; Munsung , 16. xi. 1972, from roots of unidentified grass ; **Paratypes:** 6 apterous viviparous ♀ ♀, 5 alate viviparous ♀ ♀, many apterous nymphs and alatoid nymphs, collection data same as for the holotype; 5 apterous viviparous ♀ ♀ and many apterous nymphs, India : West Bengal ; Darjeeling : Munsung, 17. i. 1972, from roots of *Ischaemum* sp. 3 apterous viviparous ♀ ♀ and 14 apterous nymphs, India: West Bengal : Darjeeling : Munsung, 16.xii. 1972, from roots of *Ischaemum* sp., 2 viviparous ♀ ♀ and 7 apterous nymphs, India: West Bengal : Darjeeling, Munsung, 17. ii. 1972, from roots of *Capillipidium perviflorum;* 15 apterous viviparous ♀ ♀ and many apterous nymphs, India : West Bengal : Darjeeling, Munsung : 23. iii. 1972, from roots of unidentified grass ; 12 apterous viviparous ♀ ♀ and many apterous nymphs, India : Sikkim : Rimbik, 20. iv. 1972 from roots of unidentified grass ; 13 apterous viviparous ♀ ♀ and many apterous nymphs, India ; West Bengal : Darjeeling Munsung, 27. iv. 1972, from roots of *Polypogon fugax;* 3 apterous viviparous ♀ ♀ and 10 apterous nymphs, India : West Bengal : Darjeeling ; Tashiding, 29. iv. 1972, from roots of *Eleucine indica;* 1 apterous viviparous ♀ and 15 apterous nymphs, India : West Bengal: Darjeeling: Munsung 22. v. 1972, from roots of unidentified grass ; 2 apterous nymphs, India: West Bengal : Darjeeling : Tashiding, 25. v. 1972, from roots of unidentified grass, 4 apterous viviparous ♀ ♀ and 2 apterous nymphs, India : West Bengal : Darjeeling : Munsung, 19. x. 1972 from roots of unidentified grass; 6 apterous viviparous ♀ ♀ and 15 apterous nymphs, India : Manipur : Kangehup, 4. iv. 1974, from roots of unidentified grass.

Remark : The genus *Chaetogeoica* was so far monotypic with *foliadentata* (Tao) and was known only by alate viviparous females. Some material collected from roots of graminaceous plants in the area have been found to fit best with the characters of *Chaetogeoica* though however, some characters particularly the tarsal chaetotaxy needs to be expanded in the alate form. The further interesting fact is the find of the same character in apterous viviparous females. The first tarsal chaetotaxy for *Chaetogeoica* as revealed now stands as 6.7.7 or 7,7,7 in

alate viviparous females and 3,2,2 in apterous viviparous female.

The present species has been considered as new to science and the alate differs from *foliodentata* (Tao) by having the ultimate rostral segment longer than second segment of hindtarsus, by the second tarsal segment being almost equal to antennal segment III and more secondary rhinaria on antennal segment III, IV and V.

Distribution : India : Manipur, Sikkim and West Bengal.

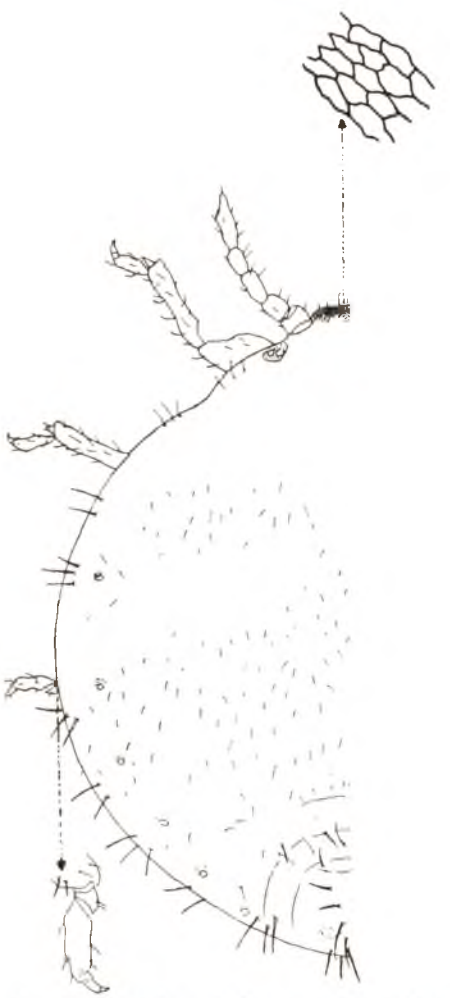

Fig. 4. *Chaetogeoica polychaeta*, sp. nov.: Aptera.

Chaetogeoica polychaeta, sp. nov. (Fig.4)

Apterous viviparous female : Body pale to pale brown, globular to oval, about 1.50–2.30 mm long, densely covered with hairs. Head pale brown, reticulated, partly free from prothorax, flat, without lateral frontal tubercle and with a very faint median dorsal longitudinal suture ; dorsal cephalic hairs with bluntish to flagellate apices and about 64μ long. Antennae 5-segmented, coloured like the head, about 0.17–0.27 × the body ; antennal segment I, II and IV nearly similar in length, segemnt V slightly over 2 × segment IV and 1.5 × segment III ; flagellum with a few spinules ; segment I with 3–4, segment II with 4–8, segment III with 4–5 hairs, the longest hair on segment III being about 60–120μ and 1.38–2.0 × the basal diameter of the segment, segment IV with 4–5 and segment V with 6–10 basal hairs with apices similar to those on the head ; processus terminalis very short, about 0.28–0.50 × the base of last antennal segment ; primary rhinaria round, slightly protuberant and ciliated. Eyes 3-faceted. Rostrum reaches hindcoxae ; ultimate rostral segment smooth, very stout and long, about 1.20–1.60 × second of hindtarsus, bearing 2–4 secondary hairs. Thorax reticulated, covered with numerous hairs ; midthoracic furca with separate arms. Abdomen pale, reticulated with indistinct segmentation ; abdominal segments 7 and 8 brown to pale brown, horse shoe shaped with open arms directed caudad and mutually separate ; dorsal hairs numerous, medium sized, placed on high sockets and irregularly arranged marginal hairs in groups of 3–6 and of these at least 1 or 2 rather stouter and longer; each of tergites 7 and 8 with 8–13 and 8–18 hairs respectively ; longest hair on abodminal tergites 1, 7 and 8 about 1.65–3.75 ×, 1.09–3.50 × and 2.15–2.35 × the basal diameter of antennal segment III respectively. Siphunculi absent. Cauda transversely oval, pale brown with 10–14 long hairs arranged in two

longitudinal rows besides a few irregularly arranged short hairs. Subanal plate pale, bilobed, each lobe bearing 7–10 long and fine hairs. Subgenital plate brown, Legs short, smooth, brown and with sparse hairs ; empodial hairs and dorsoapical hairs on second tarsal segments with subacute apices, empodial hairs about 0.50 × and dorsoapical hairs almost equal to the claws ; first tarsal segments with 3,2,2 hairs.

Measurements of the holotype in mm : Length of body 1.83, width 1.42 ; antennal segments I : II : III : IV : V 0.07: 0.07 : 0.10: 0.07 : (0.11 + 0.04) ; ultimate rostral segment 0.17 ; second segment of hindtarsus 0.12.

Holotype : Apterous viviparous ♀, INDIA : WEST BENGAL : Darjeeling ; Durbin, 13. xii. 1971, from roots of *Oryza sativa ;* **Paratypes :** 4 apterous viviparous ♀ ♀ and 3 apterous nymphs, collection data same as for the holotype. 3 apterous viviparous ♀ ♀, 19 apterous and 2 alatoid nymphs, India : West Bengal : Darjeeling : Kamshi, 3. xii. 1971, from roots of *Capillipidum* sp., 2 apterous viviparous ♀ ♀ and 11 apterous nymphs, India : West Bengal : Darjeeling : Kamshi, 14. i. 1972, from roots of unidentified grass, 5 apterous vivipraous ♀ ♀ and many apterous nymphs, India : West Bengal : Darjeeling, Kamshi, 11. ii. 1972, from roots of *Oryza sativa*, 7 apterous viviparous ♀ ♀ India : West Bengal : Darjeeling : Durban, 13. x. 1972, from roots of *Oryza sativa*, 1 apterous viviparous ♀ and 5 apterous nymphs, India : West Bengal : Darjeeling : Munsung, 19. x. 1972, from roots of unidentified grass, 2 apterous viviparous ♀ ♀, India: Manipur : Mirang, 12.iv. 1972, and 3 apterous nymphs India : Manipur : Mao, 14. iv. 1972, from roots of unidentified grass.

Remark : This new species in having ultimate rostral segment longer than second segment of hindtarsus comes close to *gramiphaga* sp. nov. but can easily be distinguished from the same by more numerous, irregularly arranged dorsal abdominal hairs.

Distribution : India : Manipur and West Bengal.

Genus *Forda* Heyden

Forda Heyden, 1837. *Ent. Beitr. Mus. Senckent.*, 2: 291

Forda trivialis Lombardi

Forda trivialis Lombardi, 1913, *Portici Bull. Lab. Zool. Gen. Agric.*, 7 : 149.

1 apterous viviparous ♀ and 14 apterous nymphs, India : West Bengal : Darjeeling : Kalimpong, 20.i.1972, from roots of *Triticum vulgare*; 1 apterous viviparous ♀ and 11 apterous nymphs, India : West Bengal : Darjeeling : Kamshi, 11.ii.1972 from roots of *Eragrostis uniloides;* 4 apterous viviparous ♀ ♀ and many nymphs, India : West Bengal Darjeeling : Kalimpong, 19.ii.1972, from roots of *Triticum vulgare;* 2 apterous viviparous ♀ ♀ and 10 apterous nymphs, India : West Bengal : Darjeeling : Tashiding, 16.iii.1972, from roots of unidentified grass; 4 apterous viviparous ♀ ♀ and 11 apterous nymphs, India : West Bengal : Darjeeling : Kalimpong, 20.iii.1972, roots of unidentified grass; 3 apterous viviparous ♀ ♀ and many apterous nymphs, India : West Bengal : Darjeeling : Kamshi, 30.iii.1972, from roots of unidentified grasses; 24 apterous viviparous ♀ ♀ and 21 apterous nymphs, India : West Bengal : Darjeeling : Munsung, 27.iv. 1972, from roots of unidentified grass; 9 apterous viviparous ♀ ♀ and 23 apterous nymphs, India : West Bengal : Darjeeling : Munsung, 22.v.1972, from roots of *Eragrostis nigra;* 10 apterous viviparous ♀ ♀ and 16 apterous nymphs India : West Bengal : Darjeeling : Kalimpong, 24.v.1972, from *Arundinacea* sp.; 5 apterous viviparous ♀ ♀ and many apterous nymphs, India :

West Bengal :Darjeeling : Mongbar, 20.vi. 1972, from roots of unidentified grass; 15 apterous nymphs, India : West Bengal : Darjeeling : Durbin, 22.vi.1972, from roots of unidentified grass. 2 apterous viviparous ♀ ♀ and 13 apterous nymphs, India : West Bengal : Darjeeling : Munsung, 24. vi. 1972 from roots of unidentified grass; 9 apterous viviparous ♀ ♀ and many apterous nymphs, India : West Bengal : Darjeeling : Tashiding, 27.vi.1972, from roots of unidentified grass; 8 apterous viviparous ♀ ♀ and 19 apterous nymphs, India : West Bengal : Darjeeling : Tashiding, 27.vi.1972, from roots of unidentified grass; 1 apterous viviparous ♀ and 2 apterous nymphs, India : West Bengal : Darjeeling : Pashke, 28.vi.1972, from rots of unidentified grass.

Apterous viviparous female : Body pale about 1·85–3·65 mm long, with transverse bands on tergites 7 and 8, Head partly fused with prothorax and distinctly spinulose dorsally; dorsal cephalic hairs stout, rather short with incrassate apices, longest hair about 0·35–0·40 × the basal diameter of antennal segment II. Antennae 5–segmented, brown, about 0·17–0·25 × the body; basal two segments smooth, segment I broader than long, segment II slightly longer than segment I and less than 0·50 × segment III; flagellum smooth on margin but stippled on surface; processus terminalis about 0·20 0·40 × the base of the last antennal segment; longest hair on segment III about 0·30–0·42 × the basal diameter of the segment. Rostrum reaches almost upto hindcoxae; ultimate rostral segment about 1·0–1·20 × second segment of hindtarsus and bears about 13–20 short and fine hairs. Meso– and metathoracic tergites with minute stipples; mesothoracic furca with separate arms. Abdominal dorsum pale with minute stipples which become distinct caudad; longest hair on abdominal tergites 1, 7 and 8 about 0·30–0·45 ×, 0·80–1·25 × and 1·15–1·45 × the basal diameter of antennal segment III respectively. Siphunculi absent. Cauda semilunar with numerous hairs. Subanal plate entire. Subgenital plate with hindmargin slightly impushed. Legs brown, smooth on margin but with minute stipples on surface; forelegs shorter than hindones; coxae and trochanters with ventral spinulosity; first tarsal segments with 6,6,6 hairs.

Measurements of one specimen in mm : Length of body 3·35, width 2·35, antenna 0·72, segments III : IV : V 0·25 : 0·11 : (0·14 + 0·04); ultimate rostral segment 0·26; second segment of hindtarsus 0·23.

Note : Material found in this region agree well with the description and fits into the Key given by Nevsky (1929). It has here been found to infest the roots of graminaceous plants.

This species is being reported for the first time from India. As the description of this species is not readily available a short description has been incoported here in the light of modern trends in aphid taxonomy.

Distribution : India : West Bengal; Caucasus; Central Asia; Europe; Israel; Lebanon; Syria; Turkey; and U. S. S. R.

Genus *Geoica* Hart

Geoica Hart., 1894. Illinois St. Ent. Rept., 18 : 101.

KEY TO THE SPECIES

Apterous viviparous female :

Processus terminalis about 0.14—0.28 × antennal segment III and about 0.19—0.36 × the base of last antennal segment; longest hair on abdominal tergite 8 about 2.85—4.20 × basal diameter of antennal segment III . . . . . *lucifuga* (Zehntner)

Processus terminalis about 0.50—0.75 × antennal segment III and about 0 40—0.65 × the base of the last antennal segment; longest hair on abdominal tergite 8 about 1.30—1.65 × the base of antennal segment III .... *sikkimensis*, sp. nov.

Geoica lucifuga (Zehntner)

Geoica lucifuga Zehntner, 1898, Suikerind. *Ned. Ind.*, 6 : 555.

Many apterous viviparous ♀ ♀ and apterous nymphs, 4 alate viviparous ♀ ♀ and 5 alatoid nymphs, India : West Bengal : Darjeeling Durbin, Ghum, Kalimpong, Kamshi, Kurseong, Mangbar, Munsung, Pashoke, Siliguri, Tashiding and Tindharia, xi. 1971–xii.1972, from roots of *Carex* sp., *Cynodon dactylon*, *Eleusine coracana*, *Eleusine indica*, *Eragrostis nigra*, *Imperata arundinaceae*, *Oryza sativa*, *Paspalum commessonii*, *Paspalum commestatum*, *Poa annua*, *Sporobolus* sp., *Triticum vulgare* and many unidentified species of grass, may apterous viviparous ♀ ♀ and apterous nymphs, India : Sikkim : Geyzing, Jorthang, Pelling Rimvik, iii.x.1972, from roots of *Cynodon dactylon* and many unidentified species of grass, many apterous viviparous ♀ ♀ and apterous nymphs, India : Manipur : Leimajhong, Kamchup, Kangpokpi, Khoirantak khumon, Mao, Moirang and Tarun, iv.1974, from roots of *Cynodon doctylon* and many unidentified species of grass.

Note : While examining large samples of this species it has been found that apterous viviparous females even in the same colony being similar in the morphometric level exhibit certain differences in the nature of body hairs. On the basis of hairs such specimens can be divided into two groups, one group with hairs of different types of apices and the other with only furcated and/or fan shaped apices. This distinct difference may lead one to treat them as two distinct apices, but we consider it a variation in a species as such variation is not uncommon in subaerial aphid species (cf. *Tetraneura*).

This species could not be found here in the gall as reported by Bodenheimer and Swriski (1957) in Middle East.

Distribution : India : Assam, Manipur, Sikkim, West Bengal; Africa; Australia Bokhara; Ceylon; China; Egypt; Israel; Java; Malaya; Pakistan; Philippines; Sierra Leone; and Taiwan.

Geoica sikkimensis, sp. nov. (Fig.5)

Apterous viviparous female: Body globular, reticulated, brownish, about 1·90– 2·05 mm long. Head brown, dorsal cephalic hairs scanty and blunt, longest one being about 20–25 long and 0·75–0·77 × the basal diameter of antennal segment III. Antennae 5–segmented, pale brown to brown, with faint wrinkles on surface except processus terminalis which is with faint spinular striae; flagellar hairs with blunt to acuminate apices, longest hair on segment III about 0·65–0.75 × the basal diameter of the segment; processus terminalis short, about 0.50–0.75 × antennal segment III and about 0·40–0·65 × the base of last antennal segment; secondary rhinaria absent; primary rhinaria protuberant, round and strongly ciliated, accessory rhinaria also ciliated; all antennal segments excepting the last one, almost similar in length and usually about 0·50–0·75 × the last antennal segment. Eyes 3–faceted. Rostrum extends up to midcoxae; ultimate rostral segment dark brown, about 1·45–1·60 × second segment of hindtarsus and bears 4 secondary hairs. Abdominal segmentation indistinct, each of tergites 7 and 8 with a horse–shoe shaped brown transverse band with the lateral margins directed caudad; dorsal abdominal hairs short, bent posteriorly, mostly with subacute

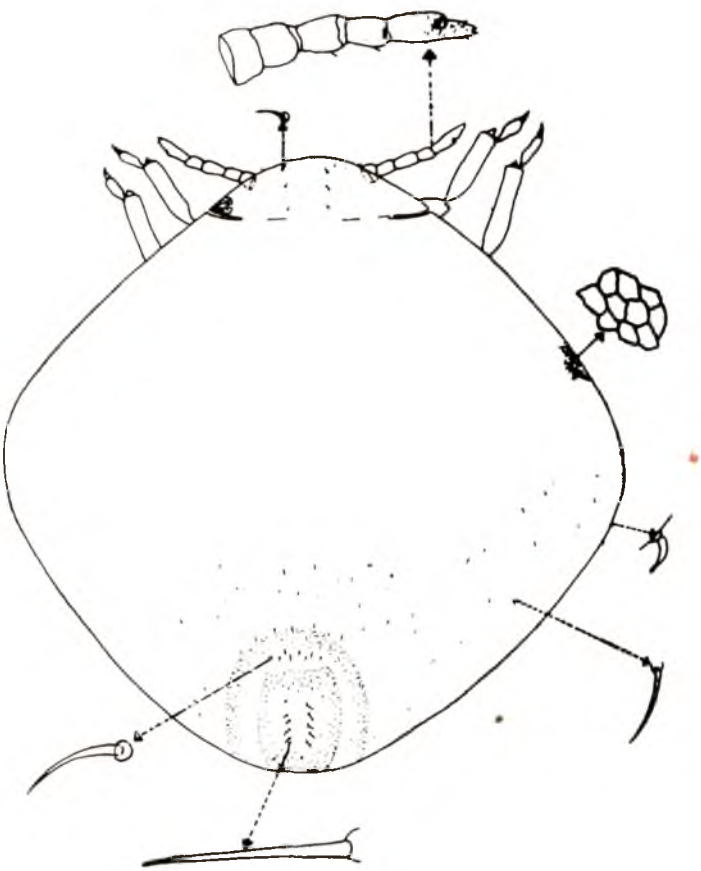

Fig. 5. *Geoica sikkimensis*, sp. nov. : Aptera.

to bluntish apices and a few with spatulate apices; segments 1–7 with 3–4 short and posteriorly bent hairs marginally; tergite 8 bear 13 long and short hairs, the longer ones with acute and shorter ones with subacute apices, longest hair on abdominal tergites 1, 7 and 8 about 0·75–0·80 ×, 1·10–1·50 × and 1·30–1·65 × the basal diameter of antennal segment III respectively. Siphunculi absent. Cauda and subanal plate rounded. Legs brown, but femora and tibiae darker; trochanter faintly indicated; femora and tibiae smooth on margin but faintly pitted on surface; hairs of second segment of tarsi long with blunt apices, empodial hairs very short and about 0·25 × the claw; first tarsal segments with 3,3,2 hairs.

Measurements of the holotype in mm : Length of body 1·92, width 1·71; antenna 0·35, segments III : IV : V 0·07:0·06: (0·08 – 0·05); ultimate rostral segment 0·15; second segment of hindtarsus 0·10.

Holotype : Apterous viviparous ♀, INDIA : WEST BENGAL, Kalimpong, 25.x.1972, from roots of *Polypogon fugax*. **Paratypes** : 1 apterous viviparous ♀ and 2 apterous nymphs collection data same as for the holotype, 2 apterous viviparous ♀ ♀ and 2 apterous

nymphs, INDIA : SIKKIM; RIMBIK, 7.x.1972, from roots of unidentified grass.

Remark : Apterous viviparous female of this species appear distinct from all other known species under the genus because of having comparatively longer processus terminalis (0·50–0·75 × the base of last antennal segment) and fewer short dorsal abdominal hairs.

Distribution : India: Sikkim and West Bengal.

Genus *Pemphigus* Hartig

Pemphigus Hartig, 1839. *Jahresber, Forest. u. Farestl–Naturk*. im Jahre 1836 u. 1837, 1(4) : 645.

Pemphigus vulgaris, sp.nov. (Fig. 6)

Apterous viviparous female : Body pale brown, oval, about 1.90–2.10 mm long. Head pale brown to brown, incompletely fused with prothorax, without lateral frontal tubercle ; dorsal cephalic hairs very short and fine, about 7-15μ long and about 0.25 - 0.40 × the basal diameter of the antennal segment III. Antennae 5-segmented, very short, about 0.15 - 0.23 × the body ; segment II always longer than segment I, segment III always longer than segment IV ; flagellum imbricated; primary rhinaria protuberant and ciliated, processus terminalis very short, about 0.19 - 0.25 × the base of last segment. Eyes

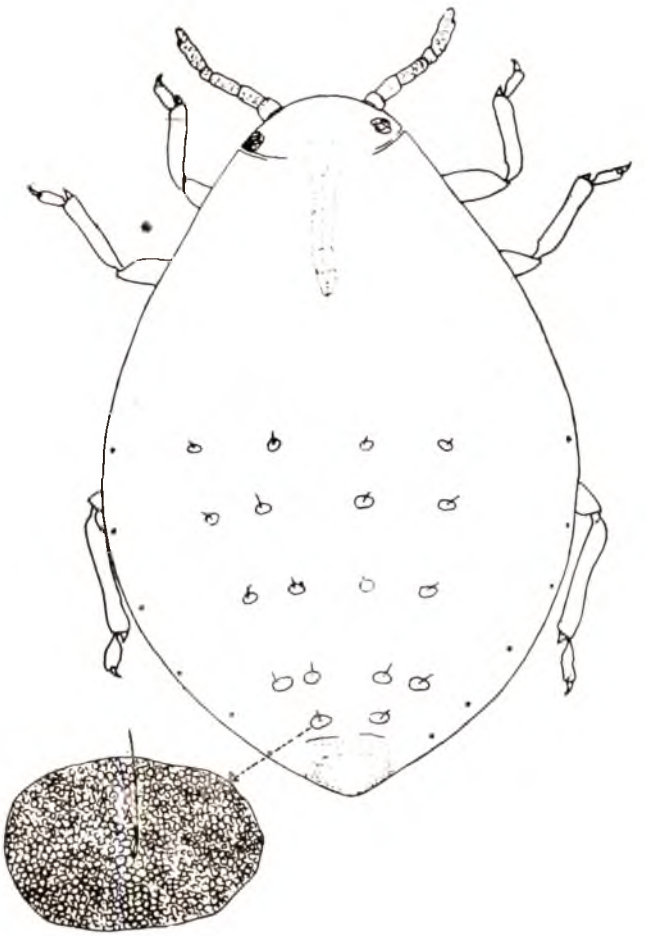

Fig. 6. *Pemphigus vulgaris*, sp. nov. : Aptera.

3-faceted.. Rostrum short, sometimes reaching midcoxae ; ultimate rostral segment short and blunt, about 0.75-0.96 × second segment of hindtarsus. Abdominal segmentation obscure ; each of abdominal segments 1–6 with variable number of wax-plates and segment 7 always with 2 large spinopleural wax-plates and all of these with indistinct pores ; tergal hairs very short and thin, hairs on tergite I about 0.30–0.46 × the basal diameter of antennal segmentIII ; 7th tergite with 1 spinal and 2 marginal short thin, fine hairs on each side, spinal hairs about 0.55 - 0.92 × the basal diameter of antennal segment III ; 8th tergite with 1 such hair spinally and 1 pleurally on each side, the spinal ones being about 0.65–1.25 × the mentioned diameter. Siphunculi absent. Cauda semicircular, bear a few short hairs. Subanal plate round. Subgenital plate with 10-12 rather long hairs. Legs with very faint imbrications and indistinct wax cells ; trochanters almost fused with femora ; tibiae with 6 stout and spiny hairs near the apex ; tarsi with sparse minute spinules ; empodial hairs very short and spine like, about 0.27 - 0.30 × the claw ; first tarsal segments with 2,2,2 hairs.

Measurements of the holotype in mm : length of body 2.01, width 1.75 ; antennal segments I:II:III:IV:V 0.06:0.07:0.11:0.05: (0.09 + 0.02); ultimate rostral segment 0.10 ; second segment of hindtarsus 0.14.

Holotype: Apterous viviparous ♀ INDIA : SIKKIM : RIMBIK, 20.iv.1972 from roots of *Triticum vulgare ;* **Paratypes :** 5 apterous viviparous ♀♀, 4 nymphs, collection data same as for the holotype ; 1 apterous viviparous ♀ INDIA : WEST BENGAL : DARJEELING: Munsung, 16.xi.1971 from roots of unidentified grass.

Remark : This new species is distinct from all other *Pemphigus* species for having longer ultimate rostral segment (about 0.75-0.96 × the second segment of hindtarsus).

Genus *Smynthurodes* Westwood

Smynthurodes Westwood, 1849. *Gardners' Chron.*, 27 : 240.

Smynthurodes betae Westwood (Fig. 7) *Smynthurodes betae* Westwood, 1849, *Gardners' Chron.*, 27 : 240.

1 apterous viviparous ♀ and 4 apterous nymphs, INDIA : WEST BENGAL : Darjeeling Pashoke, 16.ii.1972, from roots of *Setaria palmiflora*, 5 apterous viviparous ♀♀ and 6 apterous nymphs, India : West Bengal : Darjeeling : Durbin 20. v. 1792, from roots of *Cynodon dactylon*, 1 apterous viviparous ♀♀ India : West Bengal : Darjeeling : Mongbul, 18.i.1972, from roots of unidentified grass, 8 apterous nymphs, INDIA : MANIPUR : LEIMAKHONG, 3.iv. 1974, from roots of unidentified grass.

Apterous viviparous female : Body pale, oval, about 1.45 - 2.30 mm long . Head pale brown, smooth, somewhat dusky with a faint median longitudinal suture on the venter and without lateral frontal tubercle ; dorsal cephalic hairs numerous, long with finely drawn out apices, longest one about 2.35 - 2.55 × the basal diameter of antennal segment III. Antennae 5–segmented, pale brown, short and stout, about 0.25 - 0.35 × the body, smooth on margin but faintly wrinkled on surface, densely covered with long hairs having finely drawn out apices ; longest hair on antennal segment III about 1.50–2.0 × the basal diameter of the segment ; antennal segments I and IV almost equal in length, segment II more than 1.50 × segment I and almost equal to segment III, processus terminalis very short with a few spinules, about 0.15 - 0.20 × the base of last antennal segment ; secondary rhinaria absent ; primary rhinaria protuberant and nonciliated but

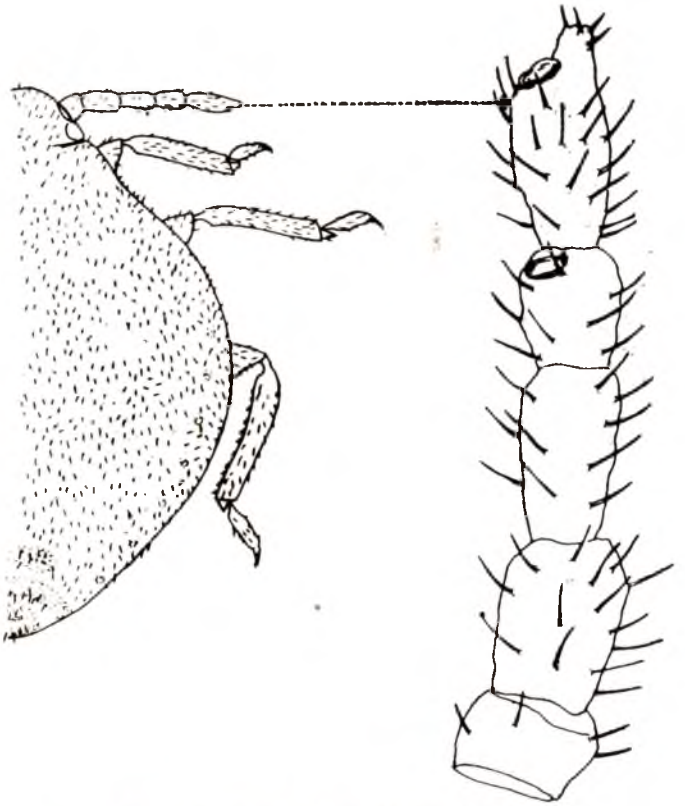

Fig. 7. *Sminthurodes betae* Westwood : Aptera.

accessory rhinaria ciliated. Eyes 3–faceted. Rostrum long, extends up to hindcoxae. ultimate rostral segment about 1.0 - 1.10 × second segment of hindtarsus and usually bears 6–8 long secondary hairs. Abdominal dorsum pale excepting segment 8 which bears a brown transverse band ; dorsal hairs numerous and long ; tergites 7 and 8 bear about 50–70 and 12–20 hairs respectively, longest one on these segments about 1.70–2.0 × and 2.0–3.15 × the basal diameter of antennal segment III respectively. Siphunculi absent. Cauda semilunar. subgenital plate entire and light brown. Legs brownish with darker tarsi, smooth except tarsi which are with sparse spinules, trochanter usually faintly indicated ; hairs on legs with fine apices ; dorsoapical hairs on second tarsal segments long with fine apices, first tarsal segments with 5,5,4 hairs.

Note : Following the remarks of Eastop (1966) the specimens collected in this region have been treated as *betae* Westwood. It may be stated here that these specimens conform with *silvestrii* group within *betae* when host plant association and number of dorsal hairs on abdominal tergite 8 are considered.

Distribution : India : West Bengal ; Africa; America ; Crimea ; Cyprus ; Egypt ; England Holland ; Iran and New Zealand..

Genus *Tetraneura* Hartig

Tetraneura Hartig, 1841. *Germans Z. Ent.*, 3 : 366.

KEY TO THE SPECIES

Apterous viviparous female :

1. Ultimate rostral segment with 4–8 secondary hairs ; at least a few of the marginal hairs on abdomen long and stout 2

—Ultimate rostral segment with never less than 10 secondary hairs ; marginal hairs on abdomen variable in length 3

2. Abdominal dorsum pale with numerous short hairs with blunt apices : antennal segment II without any hair ; ultimate rostral segment with 4–6 secondary hairs ; wax-plates not well developed ..... *basui* Hille Ris Lambers

—Abdominal dorsum pale brown with hairs sparsely distributed hairs of variable lengths and apices; antennal segment with hairs ; ultimate rostral segment with 6–8 secondary hairs ; wax-plates well developed ..... *nigriabdominalis* (Sasaki)

3. Abdominal tergite 8 with never more than 5 hairs ; ultimate rostral segment more than 3× the last antennal segment and with 15–26 hairs 4

—Abdominal tergite 8 always with more than 10 hairs; ultimate rostral segment less than 3 × the last antennal segment and bears 10–12 secondary hairs 5

4. Antennal segments II and III with up to 12 and 12–18 hairs respectively; hairs on abdominal tergites I and 8 about 2.4–2.7× and 6.2–6.85× the basal diameter of antennal segment III respectively and these are long with flagellate apices ..... *sikkimensis*, sp. nov

—Antennal segments II and III with more than 15 and 25 hairs respectively; hairs on abdominal tergites I and 8 about 1.2–1.45 × and 3.25–4.2× the basal diameter of antennal segment III respectively and these are rather short and with acute apices ..... *radicicola/yezoensis* group

5. Hairs on abdominal tergite I about 6.0–9.2× the basal diameter of antennal segment III ; antennal segments II and III with 16–18 and 40–50 hairs respectively ..... *multisetosa*, sp. nov.

—Hairs on abdominal tergite I about 1.2–1.6× the basal diameter of antennal asegment III; antennal segments II and III with 9–12 and 20–26 hairs respectively ..... *kalimpongensis*, sp. nov.

Alate viviparous female :

1. Ultimate rostral segment about 1.3–1.75 × second segment of hindtarsus and with 15–25 secondary hairs; antennal segments II and III with 13–22 and 17–28 hairs respectively; longest flagellar hairs about 2.5–3.25 × the basal diameter of antennal segment III ..... *radicicola/yezoensis* group

—Ultimate rostral segment about 0.75 × second segment of hindtarsus and with 6–8 secondary hairs; antennal segment II and III with 3–7 and 3–13 hairs respectively; longest flagellar hair atmost upto 1.5 × the basal diameter of antennal segment III 2

2. Abdominal tergite 8 with only 2 hairs; antennal segment III with 8–13 hairs; antennal segments III, IV and V with 11–15, 2–4 and 7–12 secondary rhinaria respectively ..... *nigriabdominalis* (Sasaki)

—Abdominal tergite 8 with 4 hairs; antennal segment III with 3–7 hairs; antennal segments III, IV and V with 11–14, 2–4 and 4–7 secondary rhinaria respectively in 6-segmented antenna and segments III and IV with 14–27 and 5–9 secondary rhinaria respectively in 5-segmented antennae ..... *basui* Hille Ris Lambers

Tetraneura basui Hille Ris Lambers

Tetraneura (*Tetraneurella*) *basui* Hille Ris Lambers, (1968–69). 1970. *Boil. Zool. Agr. Brachicolt.*, 2(9) : 44.

Many apterous viviparous ♀ ♀ and apterous nymphs, 7 alate viviparous ♀ ♀ and 70 alatoid nymphs, INDIA: WEST BENGAL: Darjeeling: Durbin, Kalimpoing, Kamshi, Mongbar, Mongbul, Munsung, Pashoke and Tashiding, xi. 1971– x. 1972, from roots of *Capillipidium* sp., *Echinochloa colonum*, *Eleusine indica*, *Oryza sativa*, *Pagonantherum saccharum*, *Paspalum commessonii*, *Paspalum conjugatum*, *Polypogon monspeliensis*, *Setaria glauca*, many unidentified species of grasses 27, apterous viviparous ♀ ♀ and 24 apterous

nymphs, INDIA: SIKKIM: Rimbik, 20.x.1972, from unidentified species of grasses; many apterous viviparous ♀♀, 20 alate viviparous ♀♀, and 18 apterous nymphs, INDIA: MANIPUR: Kangchung, Keibul; Leimakhong and Tarun, iv. 1974, from roots of many unidentified species of grass.

Apterous viviparous female: Body globular about 1.30–2.15 mm long, pale brown. Head smooth, somewhat free from prothorax, dorsum with median longitudinal suture; dorsal cephalic hairs stout, about 1.20–2.90 × the basal diameter of antennal segment III. Antennae brown, about 0.15–0.20 × the body, usually 5–, rarely 4 – segmented; antennal segment II in 5–segmented antennae without any hair but in 4–segmented antennae with 4–5 apical hairs; longest flagellar hair about 0.85–1.50 × the basal diameter of antennal segment III; segment III sparsely and other flagellar segments densely spinulose; processus terminalis about 0.5 × the base of last antennal segment. Rostrum reaches midcoxae; ultimate rostral segment short with spinules, about 1.45–2.15 × the last antennal segment, with 4–6 flagellate secondary hairs. Midthoracic furca with separate arms. Each of andominal tergites 7 and 8 with a semicircular transverse band; anterior abdominal tergites with numerous hairs having blunt apices, longest one being about 1.80–2.90 × the basal diameter of antennal segment III; tergite 7 usually with 4–6 spinopleural hairs, longest of these about 2.70–3.65 × the basal diameter of antennal segment III, tergite 8 with a pair of very long spinal hairs besides 2–6 rarely 7 marginal hairs, longest spinal hair about 3.20–4.45 × the mentioned diameter; wax-plates variable in size. Cauda brown, with 6 hairs. Subgenital plate depressed medially forming two lateral lobes, each lobe with 8–12 hairs. Legs brown, ventrally with a few spinules; trochanters indistinctly fused with femora; dorsoapical hairs on the hindtarsus always shorter than the claw; empodial hairs about 0.85–1.0 × the claw.

Alate viviparous famale: Body pale. Head dark brown; cephalic dorsum with 6 hairs having blunt apices, these about 2.15–3.60 × the basal diameter of antennal segment III. Antennae 5– or 6–segmented, dark brown, about 0.24–0.37 × the body; antennal segment I with 2 stout and long and 1 fine and short hairs, segment II with 3–7 hairs; segment III with a few spinules at apex and all other flagellar segments with dense spinules; in 5–segmented antennae segment III with 3–6 short and fine hairs and in 6–segmented antennae with 4–7, segment IV in 5–segmented antenna with 4 such hairs and in 6–segmented antennae with 1–3 hairs, last antennal segment always with 3 basal hairs; processus terminalis very short, about 0.35–1.60 × the base of the last antennal segment; primary rhinaria small and rounded, densely ciliated and slightly protuberant; secondary rhinaria nonciliated, subannular, in 5–segmented antennae segments III and IV with 14–17 and 5–9 such rhinaria respectively and in 6–segmented antennae segments III, IV and V with 11–14, 2–4 and 4–7 such rhinaria respectively. Eyes multifaceted. Rostrum usually reaches middle of mesothorax; ultimate rostral segment short, about 0.60–0.75 × second segment of hindtarsus. Abdomen pale with indistinct segmentation, each segment bears marginally a pair of hairs with subacute to blunt apices and these are usually about 0.06 mm long; dorsal hairs on tergite 1 rather short with blunt apices, about 2.0–3.80 × the basal diameter of antennal segment III; 7th tergite with a pair of long hairs having subacute apices marginally and also spinally, longest spinal hair about 2.65–4.55 × the mentioned diameter; tergite 8 with a dark brown semicircular transverse band which on segment 7 very faint, bears a pair of long and stout spinal

hairs as on segment 7 and with a pair of very short marginal hairs, longest spinal hair about 3.0–5.90 × the mentioned diameter. Mesothorax to abdominal segment 7 marginally with a round to oval faint wax plates, these being composed of round cells distinctly separated from each other, these wax plates gradually becoming larger posteriorly, spinopleural wax-plates not discernible. Siphunculi conical with a well chitinized rim. Cauda almost semioval, dark brown. Subgenital plate brown, large and oval with 25–35 hairs. Legs long, brown, covered with a few short hairs; trochanters free, coxae and trochanters ventrally and femora apically with a few spinules; tarsal segments long with acuminate apices, about 0.90–0.95 × the claw; first tarsal segments usually with 3,2,2 and rarely with 3,3,2 hairs. Forewings pale, with media simple and arising from middle, subcosta with a row of short and fine hairs; hindwings with 1 oblique vein.

Measurements of one specimen (with 5-segmented antennae) in mm: Length of body 1.81, width 0.91; antennal segments I:II:III:IV: V 0.05:0.05: 0.29: 0.15: (0.05 + 0.03) ultimate segment 0.10; second segment of hindtarsus 0.15.

Measurements of one specimen (with 6-segmented antennae) in mm: Length of body 1.72, width 0.75; antennal segments I:II:III:IV:V:VI: 0.05: 0.05: 0.20: 0.07: 0.12: (0.05 + 0.02); ultimate rostral segment 0.09; second segment of hindtarsus 0.13.

Remark : Hille Ris Lambers (1968–69) described *Tetraneura basui* from apterous viviparous female and embryos only. Availability of large number of apterous viviparous females has necessitated some changes in the original description and thus it has here been redescribed. The hitherto unknown alate viviparous female is also described here.

Distribution : India: Manipur, Nagaland, and West Bengal.

Tetraneura kalimpongensis, sp. nov. (Fig.8)

Apterous viviparous famale : Body pale, globular, about 1.75–2.10 mm long. Head brown, slightly wrinkled on dorsal surface, somewhat free from prothorax, without lateral frontal tubercles, ventrally with a pair of elongated wax-plates, each usually being composed of two rows of almost equal sized wax cells; ventromedian longitudinal suture prominent; 8–10 long and stout dorsal cephalic hairs present, longest one being about 2.30–8.15 × the basal diameter of antennal segment III. Antennae 4-segmented, brown, about 0.15–0.20 × the body; antennal segment I as long as segment II, with a few spinular striae distally and segment IV sparsely spinulose, other segments smooth; segment I with 6–8, segment II with 9–12, segment III with 20–26 fine hairs, respectively, longest one on segment III being about 1.75–2.0 × the basal diameter of the segment; last antennal segment indistinctly separated from segment III and bears basally 4–7 hairs similar to those on other segments; primary rhinaria round and ciliated; processus terminalis very short, about 0.40–0.65 × the base of last antennal segment. Eyes 3-faceted. Rostrum just passes midcoxae; ultimate rostral segment short, sparsely spinulose, about 1.70–2.25 × the last antennal segment and bears 10–12 long and stout secondary hairs having acute apices. Pro- and mesothorax marginally with numerous long and stout hairs which are about 1.10–1.20 mm long; midthoracic furca sessile. Abdomen pale with indistinct segmentation ; marginal hairs on abdomen long, the number increasing caudad and the dorsal hairs much shorter than marginal ones, abdominal tergite 1 with a few shorter hairs having blunt apices, longest one being about 1.20–1.50 × the basal diameter of antennal segment III; each of segments 7 and 8 with a brown semicircular transverse band; tergite 7 bears 16–23 and tergite 8 with

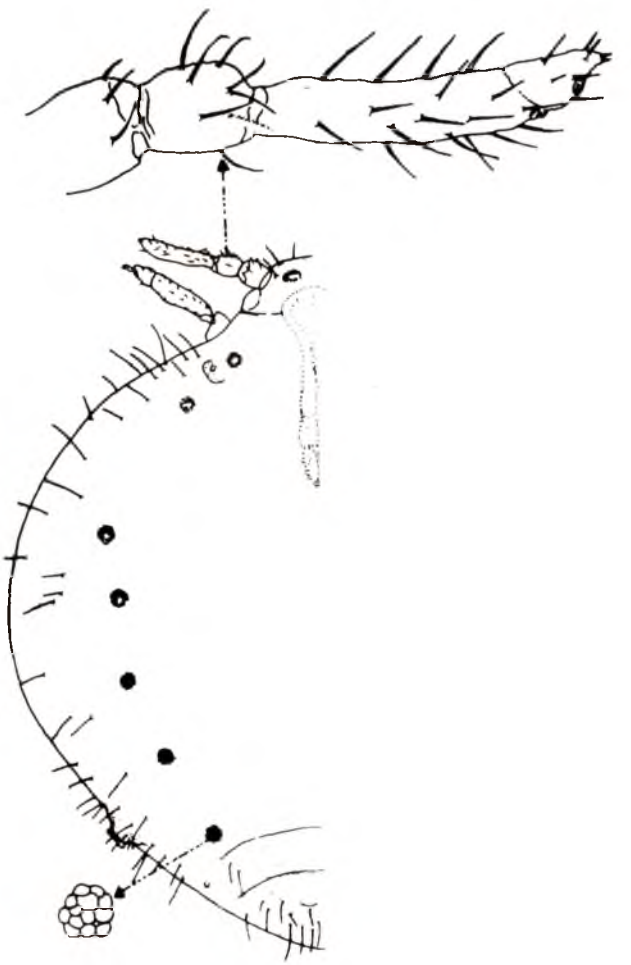

Fig. 8. *Tetraneura kalimpongensis*, sp. nov. : Aptera.

12–14 long and stout hairs with subacute to acute apices, longest one on segment 7 about 2.35–2.75 × and on segment 8 about 2.10–3.75 × the basal diameter of antennal segment III respectively; wax-plates of variable sizes, cells in each plate nearly equal, these usually leave a central area free, in smaller plates free area more peripherally situated, wax-plates placed pleurally usually longer than those placed spinally. Siphunculi conical, brown, with a chitinized rim. Cauda dark brown, broad, slightly bluntly conical and bears 6 long hairs. Subanal plate small, dark brown and semicircular. Subgenital plate broad, pale, usually medially impushed forming apparently two lateral lobes, each bearing 12–15 long and stout hairs. Legs brown, smooth, densely covered with hairs similar to those on antennae; trochanters indistinctly separated from femora; dorsoapical hairs on hindtarsi and empodial hairs long with acuminate apices, the latter about 1.10–1.20 × the claw.

Measurement of the holotype in mm: Length of body 1.93, width 1.72; antennal segments I:II:III:IV: 0.07:0.07: 0.17:(0.04 + 0.02); ultimate rostral segment 0.11.

Holotype : Apterous viviparous ♀, INDIA: WEST BENGAL: Darjeeling: Kalimpong, 20.v. 1972, from roots of *Saccharum officinarum;* **Paratypes :** 13 apterous viviparous ♀♀, 36 apterous and 7 alatoid nymphs, collection data same as for the holotype; 11 apterous viviparous ♀♀ and 17 apterous nymphs, India: West Bengal: Darjeeling: Toshiding, 25.v. 1972, from roots of *Pennisetum* sp.

Remark : This species comes close to *Tetraneura javensis* van der Goot but differs in having shorter dorsal hairs on first abdominal segment and longer hairs arranged marginally.

Distribution : India: West Bengal.

Tetraneura multisetosus, sp. nov. (Fig. 9)

Apterous viviparous female: Body globular, brown, about 1.40–1.86 mm long. Head brown, somewhat fused with prothorax with prominent median longitudinal suture, ventrally with a pair of well defined wax-plates containing rather indistinct cells and dorsally with very fine spinules; dorsal cephalic hairs numerous, very long and stout with flagellate apices, longest one about 2.80–5.35 × the basal diameter of antennal segment III. Antennae brown, 4-segmented, about 0.24–0.28 × the body; segment III near apex and the last segment with a few spinules; segment I as long as segment II, about 0.30 × segment III and bears 10–12 hairs, segment II with 16–18 hairs and segment III with 40–50 hairs, the longest of these about 1.60–3.35 × the basal diameter of the segment, base of the last antennal segment with 3–5 such hairs; processus terminalis very short; primary rhinaria very small and round, strongly ciliated and non-protuberant. Eyes 3-faceted. Rostrum just reaching midcoxae; ultimate rostral segment short, with spinules and 10–12 long secondary hairs, about 1.70–2.15 × the last antennal segment. Thoracic segments with very long

Fig. 9. *Tetraneura multisetosa*, sp. nov. : Aptera.

hairs, longest one being placed on the margin; midthoracic furca sessile. Abdomen brown, with indistinct segmentation; longer abdominal hairs present on anterior tergites as well as on margin upto siphunculi, these hairs become shorter caudad, longest hair on andominal tergite I about 6.0–9.20 × the basal diameter of antennal segment III, such spinal hairs on tergites 7 and 8 about 2.0–4.50 × and 2.40–5.0 × the mentioned diameter respectively; a brown transverse band present on each of abdominal tergites 7 and 8, these tergites with 20–26 and 10–15 hairs respectively, hairs on the margin about 230–280 μ long; wax-plate of variable sizes and cells in each plate so arranged that the central area is devoid of any cell. Siphunculi brown with well chitinized dark brown rims. Cauda brown, almost triangular with 8–10 long hairs. Subgenital plate pale brown, large, transversely oval, bearing more than 25 long hairs. Legs brown; femora smooth, densely covered with rather short hairs; trochanters indistinctly separated from femora; tibiae distally

and tarsi with a few spinules; dorso-apical hairs on hindtarsi and empodial hairs long with acuminate apices being about 1.10–1.25 × the claw.

Measurements of the holotype in mm: Lenth of body, 1.56. width 1.26; antennal segments I.II.II:IV 0.08:0.06: 0.21: 0.06; ultimate rostral segment 0.13.

Holotype : Apterous viviparous ♀. INDIA: WEST BENGAL: Darjeeling: Pashoke, 24.i. 1972 from roots of *Capillipidium perviflorium:* **Paratypes:** 3 apterous viviparous ♀ ♀ and 16 apterous nymphs, collection data same as for the holotype, 1 apterous viviparous ♀ ♀ and 11 apterous nymphs, India: West Bengal: Darjeeling, Pashoke, 16 ii. 1972 from roots of unidentified species of grass, 4 apterous viviparous ♀ ♀, India: West Bengal: Darjeeling, Pashoke, 28.vi. 1972 from roots of *Imperata cylindrica*, 7 apterous viviparous ♀ ♀ and 3 apterous nymphs, India: West Bengal: Darjeeling: Tashiding, 27. vi. 1972, from roots of unidentified species of grass.

Remark : This species differs from its morphologically allied species *Tetraneura javensis* van der Goot in having more numerous and long body hairs and from *T. kalimpongensis* sp. nov. by more numerous long hairs spino-pleurally on anterior tergites.

Distribution : India: West Bengal.

Tetraneura nigriabdominalis (Sasaki)

Schizoneura nigriabdominalis Sasaki, 1899. *Hand book of Insect pests of crops in Japan* 435.

Many apterous viviparous ♀ ♀, alate viviparous ♀ ♀ and apterous and alatoid nymphs, INDIA : WEST BENGAL : Darjeeling, Durbin, Ghum, Kalimpong, Kamshi, Kurseong, Mahanadi, Mongbar, Mongbul, Munsung, Pashoke, Sephkola, Siliguiri, Tashiding, and Tindharia, xi. 1971 – x. 1972, from roots of *Axonopus compressus*, *Brachiaria remosa*, *Brachiaria* sp., *Capillipidium perviflorum*, *Capillipidium* sp., *Chrysopogon aciculatus*, *Cynodon dactylon*, *Cynodon* sp., *Dactyloctinium aegypticum*, *Digitaria* sp., *Echinochloa colona*, *Eleusine coracana*, *E. indica*, *Eragrostris gangetica*, *E. nigra*, *E. temella*, *Imperata arundinaceae*, *I. cylindrica*, *Oplismenus barmanui*, *Oryza sativa*, *Paspalum commenssonii*, *P. conjugatum*, *Paspalum* sp., *Pogonentherum saccharoideum*, *Polypogon fugex*, *P. monspellensis*, *Setaria glauca*, *Triticum vulgare* and many unidentified species of grasses, many apterous viviparous ♀ ♀, alate viviparous ♀ ♀ and apterous and alatoid nymphs, INDIA : SIKKIM: Geyzing, Jorethang, Pelling and Rimbik, iv–x, 1972, from roots of *Cynodon dactylon* and many unidentified species of grasses, many apterous viviparous ♀ ♀, alate viviparous ♀ ♀, and apterous and alatoid nymphs, INDIA: MANIPUR : Iroisemba, Mahabali forest, Mao, Maoirang, Kangchup, Kangpokpi, Keibul, Tarun and Uripok, iv. 1974, from roots of *Cynodon dactylon* and many unidentified species of grasses, many apterous viviparous ♀ ♀, alate viviparous ♀ ♀ and apterous and alatoid nymphs, INDIA: NAGALAND: Kohima, iv. 1974, from roots of *Cynodon dactylon* and many unidentified species of grasses.

Apterous viviparous female : Body pale to pale brown, about 1.55–2.35 mm long. Head somewhat fused with prothorax, usually smooth, rarely scabrous, sometimes with a pair of poorly developed lateral elevation and with faint median dorsal longitudinal suture; dorsal cephalic hairs about 100μ long and about 1.4 – 2.45 × the basal diameter of antennal segment III. Antennae 3– to 5–segmented, about 0.15–0.21 × the body; segment II rarely with 5–7 hairs; segment III, if separate with 0–3 hairs, and when fused with the next segment bears 15–20 apical hairs; segment IV when recognizable separately bears 15–21 hairs; longest flgellar

hair about 40 μ long and 1.0 – 1.65 × the basal diameter of antennal segment III; penultimate and ultimate segments with spinules; primary rhinaria round and densely ciliated. Ultimate rostral segment blunt, about 1.75 – 2.45 × the last antennal segment and with 6–8 secondary hairs. Abodmen pale to pale brown, longest marginal hair about 53μ long with subacute, blunt or capitate apices ; longest spino-pleural hair on abdominal tergites 1.7 and 8 about 68μ, 70–165μ and 155–290μ long and about 0.55 – 2.80×, 1.70 – 4.65 × and 6.20 – 6.80 × the basal diameter of antennal segment III respectively; each of tergites 7 and 8 with a transverse, brown semicircular band; segment 7 with a pair of lateral abdominal tubercles; wax-plates very variable. Siphunculi brown, conial with well chitinized rim. Cauda brown, bluntly conical with 4 stout hairs. Subgenital plate medially impushed forming the lateral lobes, each of these with 10–18 hairs. Legs brown, smooth; trochanters indistinctly separated from femora; dorso-apical hairs on hindtarsal segment and empodial hairs long with acuminate apices and about 1.0 – 1.20 × the claw.

Measurements of one specimen (with 3–segmented antennae) in mm : Length of body 1.90, width 1.69; antennal segments I:II:III 0.06:0.07:0.20; ultimate rostral segment 0.12.

Measurements of one specimen (with 4–segmented antennae) in mm : Length of body 1.98, width 1.72; antennal segments I:II:III:IV 0.07 : 0.07 : 0.22 : 0.06; ultimate rostral segment 0.11.

Measurements of one specimen (with 5–segmented antennae) in mm: Length of body 2.32, width 1.86; antenna 0.43, segments III : IV : V 0.09 : 0.15 : 0.06 ; ultimate rostral segment 0.13.

Alate viviparous female : Head dark brown; dorsal cephalic hairs about 24μ long and 1.10 – 2.0 × the basal diameter of antennal segment III. Antennae 6–segmented, dark brown, about 0.28 – 0.34 × the body; antennal segment III about 4.0 × segment I and with 8–13 hairs, longest of these being about 17μ and 0.80 – 1.25 × the diameter of ahe segment IV almost equal to segment I, segment V slightly shorter than segment III and with 13–20 hairs, segment IV sparsely and segments V and VI densely spinulose; segments III, IV and V with 11–15, 2–4 and 7–12 non-ciliated, subannular secondary rhinaria respectively, eyes multifaceted with reduced triommatidia. Ultimate rostral segment sparsely spinulose, about 0.60—0.75 × second segment of hindtarsus. Longest dorsal hair on abdominal tergites 1,7 and 8 about 37μ, 41μ and 97μ long respectively longest marginal hair about 75μ; tergite 7 with 2–3 short and blunt spinopleural hairs, tergite 8 with only 2 hairs having flagellate to subacute apices. Legs dark brown; femora ventrally and tibiae apically with a few spinules; second tarsal segment densely spinulose; dorso-apical hairs on second tarsal segment short, about 0.50–0.70 × the claw. Media of forewings arising from the middle of the wing. Otherwise as in apterous viviparous female.

Measurements of one specimen in mm: Length of body 2.12, width 1.17; antenna 0.67, segments III:IV:V:VI 0.21 : 0.07: 0.20:0.06; ultimate rostral segment 0.10; second segment of hindtarsus 0.15.

Note : A large sample of *nigriabdominalis* collected in this region though conforms broadly with the conception of *nigriabdominalis* reveals considerable graded variations in some characters. As one of such examples it can be mentioned that the number of hairs on abdominal tergite 8 varies from 2 to 6 without showing any discrete gap between the lower and upper limits.

Therefore, erection of the subspecies *bisipina* by Hille Ris Lembers (1968–69) basing on such character becomes difficult to reconcile. It is for this reason a redescription of the species based on the present collection has been provided here with a view to show the range of variation in a particular character.

However, some indications are there to show that the population can be grouped into 2 categories. Those are: (i) specimens with cephalic hairs having swollen apices marginal hairs with different types of apices and abdominal dorsum smooth and (ii) specimens with cephalic hairs having subacute apices, marginal hairs from mesothorax, caudad having only swollen apices and abdominal dorsum with distinct reticulate pattern.

The above distinctions in morphological characters of apterous viviparous females has not been considered here to be of taxonomic significance since such distinction can be found in one and the same colony.

Distribution : India: Arunachal Pradesh, Assam, Manipur, Meghalaya, Nagaland, Sikkim, West Bengal; Africa; Australia; Cameroons; Ceylon; Egypt; Jamaica; Japan; Malaya ; Pakistan ; Philippines ; Sabah ; Sierre Leon and U.S.S.R.

Tetraneura radicicola / yezoensis group

Tetraneura radicicola Strand, 1919, *Acta Univ. Latvensis*, 20:22.

Tetraneura yezoensis Matsumura, collection of Essays for Nawa Gifu, 3:73.

Many apterous viviparous ♀ ♀ , alate viviparous ♀ ♀ and apterous and alatoid nymphs, INDIA : WEST BENGAL : Darjeeling, Durbin, Ghum, Kalimpong farm, Kamshi, Kurseong, Mahanadi, Mongbar, Mongbul, Munsung, Pashoke, Tashiding and Tindharia, xi. 1971–x. 1972, from roots of *Bracharia ramosa*, *Capillipidium* sp., *Echinochloa crusgalli*, *Eleusine coracana*, *Eragrostis gangtica*, *E. tenella*, *Imperata arundinacea*, *I. cylindrica*, *Pogonentherum saccharum*, *Polypogon fugax*, *Setaroa glauca*, *Triticum vulgare* and many unidentified species of grasses, 5 apterous viviparous ♀ ♀ , many apterous and alatoid nymphs, INDIA: MANIPUR: Kangchup, 4.iv. 1974, from roots of unidentified species of grass.

Apterous viviparous female: Body pale brown, about 2.15–2.55 mm long. Head brown with a pair of wax–plates, each with 7–10 rather oval cells of more or less equal size, somewhat fused with prothorax, without lateral frontal tubercles, densely covered with long hairs dorsally, longest one being about 56–64 μ and 1.50–1.70 × the basal diameter of antennal segment III. Antennae short, 5–segmented, abot 0.20–0.30 × the body; segment II always longer than segment I and about 0.75 × segment III, segment IV always more than 1.50 × segment III, segment V shortest; antennal hairs as on the anterior abdominal tergites; segment I with 5–8, segment II with 16–24 hairs, segment III smooth with 25–38 hairs, the longest one being 1.20–1.55 × the basal diameter of the segment, segment IV with 32–49 hairs and a few apical spinular striae, segment V basally with 3 hairs and a few spinules; secondary rhinaria absent; primary rhinaria small rounded and densely ciliated; processus terminalis very short. Rostrum reaches midcoxae; ultimate rostral segment usually with spinules along the stylet groove, bears 15–26 long secondary hairs and about 4.10–4.70 × the last antennal segment. Thoracic segments with marginally placed wax-plates similar to those on head. Midthoracic furca sessile. abdomen pale brown with indistinct segmentation upto segment 6; each of tergites 7 and 8 with a brown semicircular transverse band; anter-

ior tergites densely covered with hairs, tergites 5 to 8 with 1–2 long and stout marginal hairs, tergite 7 rarely with only one such hair, these about 170 μ long, beside these, each of segments 1–6 with 15–30 marginal group of short hairs which on segment 7 never exceed 4; the spinopleural hairs on tergites 7 (4–9) and 8 (2–4) rather long but shorter than the marginals; longest dorsal hair on tergite I about 1.20–1.45 × the basal diameter of antennal segment III; longest spinoplerural hair on tergites 7 and 8 about 63 – 142 μ, 135–170 μ and 1.50 – 3.80 ×, 3.25 – 4.40 × the mentioned diameter respectively; segments 1–7 marginally with usually 1, sometimes 2 wax plates of variable sizes, each being composed of numerous minute cells. Siphunculi conical with well chitinized brown rims. Cauda dark brown, bluntly conical bearing 6 long and stout hairs. Subgenital plate large, pale, usually medially impushed forming two apparent lateral lobes, each of these bearing 10–14 long hairs. Legs brown densely covered with rather short hairs having fine apices; trochanters indistinctly separated from femora; both of coxae and trochanter with a basal transverse row of well developed elongated wax cells; femora with a longitudinal row of wax cells similar to those on proximal segments; dorsoapical hairs on hindtarsal segment and empodial hairs long with acuminate apices and the latter about 1.05 – 1.35 × the claw.

Measurements of one specimen in mm: Length of body 2.43, width 1.89; antenna 0.51, segments III:IV:V: 0.13:0.21:0.05; ultimate rostral segment 0.23.

Alate viviparous female : Body pale, elongated, about 1.75 – 2.15 mm long. Head dark brown, free from prothorax, smooth, dorsum with 8–10 hairs which are about 48–68μ long and 3.25–4.50 × the basal diameter of antennal segment III. Antennae 6–segmented, brown, about 0.30–0.35 × the body; segments II and IV almost equal and always longer than segment I, segment V never less than 2.0 × segment IV and usually slightly longer than segment III; segment I with 5–8, II with 12–22, III with 17–28 hairs, longest of these about 45 μ and 2.50–3.25 × the basal diameter of the segment, segment IV with 12–21, V with 39–51 and base of last segment with 3 hairs respectively; flagellar segments with transverse spinular imbrications; secondary rhinaria subannular, nonciliated, distributed over segments III, IV, V as 6–12, 2–4, and 6–10 respectively and last segment always without such rhinaria. Eyes with reduced triommatidia. Rostrum extends upto hindcoxae; ultimate rostral segment short, about 1.30–1.75 × second segment of hindtarsus, and about 3.15–3.95 × last antennal segment. Thoracic and abdominal dorsum upto segment 6 marginally with numerous long hairs similar to those on anterior abdominal tergites; segment 7 marginally with a long hair which is about 113 μ long besides 3–5 shorter ones, longest spinopleural hair on tergites I and 7 about 56 μ and 56–90 μ and about 3.0–3.75 ×, 3.75–6.0 × the basal diameter of antennal segment III respectively, 8th tergite with 2 rather short spinal and 2 long and stout marginal hairs, longest one about 97–161 μ and 6.50–10.75 × the maentioned diameter; thoracic and abdominal tergites marginally with variable number of wax-plates composed of numerous minute wax cells. Cauda with 2 stout hairs. Subgenital plate broad and elongate oval, brown and with about 24 stout hairs. Legs long, moderately covered with hairs having fine apices; tibiae apically and tarsal segments entirely densely spinulated; dorso-apical hairs on second tarsal segments and empodial hairs with acuminate apices and the latter almost as long as the claw; first tarsal segments with 4,2,2 hairs. Media of forewings arising from the middle, subcosta with a row

of very short hairs having fine apices; hindwings with one very faint oblique vein. Other characters as in apterous viviparous female.

Measurements of one specimen in mm: Length of body 1.95, width 0.87; antennal segments III:IV:V:VI 0.18:0.07:0.22:0.66; ultimate rostral segment 0.19; second segment of hindtarsus 0.14.

Note : *Tetraneura radicicola* Strand and *T. yezoensis* Matsumura have been recognized as two distinct species even recently by Hille Ris Lambers (1968–69). The differentiating characters of the apterous viviparous females and of other morphs of these two species have been given by Hille Ris Labmbers (op. cit.). The specimens of the present collection, however, do not fit with differentiating characters for apterous sexuales because of considerale overlapping of characters, viz., the number of hairs on the antennal segment IV and the type of hairs on the margin and also their number on abdominal segment 7. It has, for these reasons been deemed fit to consider these specimens as belonging to *radicicola/yezoensis* group. Incidentally, it may be noted that Hille Ris Lambers (1967) earlier opined that *radicicola* Strand might be the same as *yezoensis* Matsumura, basing on emigrant from *Ulmus* sp. It may also be pointed out here that Dr. V. F. Eastop of the British Museum, London when approached for comments on these specimens pointed out that these belong to *radicicola/yezoensis* group.

Distribution : India : Assam, Manipur, West Bengal; California; Ceylon; Japan Malaya; Nepal; Philippines and Taiwan.

Tetraneura sikkimensis, sp. nov. (Fig.10)

Apterous viviparous female : Body pale, nearly globular, abot 1.85–1.90 mm long. Head smooth, pale brown, somewhat fused with prothorax, without wax-plates, bears 12–15 long,fine dorsal hairs placed on high sockets, these being about 2.55–2.65 × the basal diameter of antennal segment III; median dorsal longitudinal suture present. Antennae brown, 5–segmented, about 0.18–0.24 × the body, segment II longer than its width and longer than segment I, segment III usually about 0.50 × segment IV, flagellum sparsely spinulose, segment I with 4–5 long flagellate hairs, segments II, III, IV and base of V with 7–9, 12–16, 18–30 and 3 similar hairs respectively, longest hair on segment III about 2.0–3.10 × the basal diameter of the segment, processus terminalis short, about 0. 40 — 0.65× the base of the last segment, primary rhinaria round and densely ciliated. Rostrum extends slightly beyond midcoxae, ultimate rostral segment sparsely spinulose, bearing 16–18 long secondary hairs and about 3.40–4.75 × the last antennal segment. Midthoracic furca sessile. Thoracic and abdominal tergites densely covered with long flagellate hairs; wax plates of variable sizes and composed of minute cells arranged marginally from mesothorax to abdominal tergite 7; each abdominal tergite excepting tergites 7 and 8 with 8–14 long and fine hairs in groups, segment 7 with 2–5 such hairs marginally and with 5 hairs spinopleurally, longest dorsal hairs on this tergite about 2.30–3.30 × the basal diameter of antennal segment III, tergite 8 with 2–4 long and stout hairs spinopleurally, longest one being 6.20–6.90 × the mentioned diameter. Siphunculi conical with well developed chitinized rims. Cauda brown, bluntly conical, bears 6 long and stout hairs. Subgenital plate slightly impushed medially forming two apparent lateral lobes, each of these with 8–10 long flagellate hairs. Legs brown, smooth with hairs similar to those on antennae; trochanters indistinctly separated from femora; dorsoapical hairs on hind

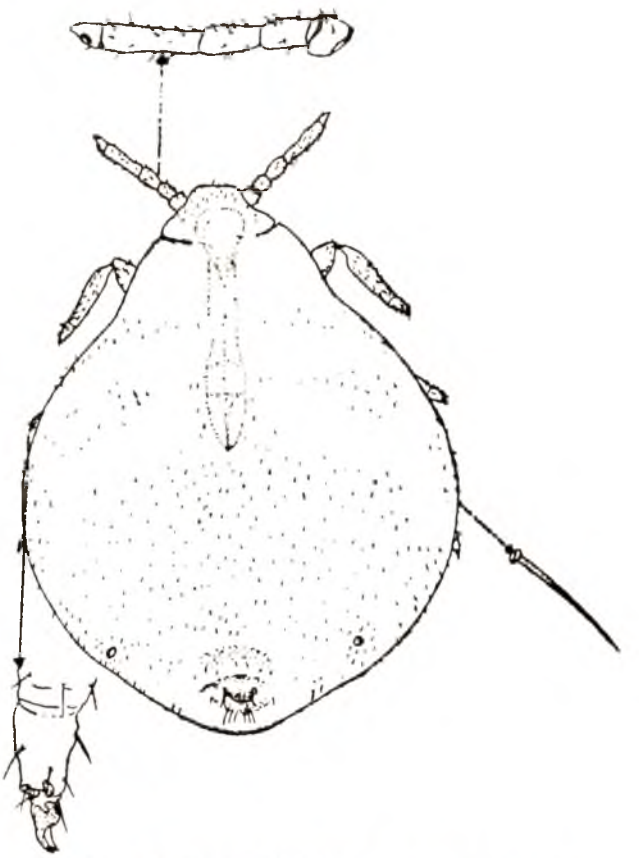

Fig.10. *Tetraneura sikkimensis*, sp. nov. : Aptera.

tarsal segment and empodial hairs long with acuminate apices and the latter about 1.0 1.20 × the claw.

Measuremets of the holotype in mm: Length of body 1.87, width 1.44; antennae 0.39, segments III: IV: V 0.08 : 0.14: (0.03 + 0.02) ultimate rostral segment 0.17.

Holotype : Apterous viviparous ♀, INDIA : SIKKIM : Geyzing, 22.iv.1972, from the roots of *Eragrostis nigra*; **paratyes** : 2 apterous viviparous ♀ and 10 apterous nymphs, collection data same as holotype.

Remark : This new species differs from its closest species *T. radicicola/yezoensis* group in possessing less numerous body hair which are much longer with flagellate apices. Moreover, it does not bear long and stout marginal hairs excepting on abodminal tergites 7 and 8 and the latter tergite also bears 2–4 stout and longer hairs spinopleurally.

Distribution : India : Sikkim.

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APHIDS (HOMOPTERA : APHIDIDAE) OF NORTH WEST INDIA: NEW SUBGENUS, NEW SPECIES AND NEW RECORDS OF ROOT INHABITING APHIDS

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Two new species viz., *Anoecia himalayensis* and *Tetraneura* (*Indotetraneura lambersi*, infesting grass roots are described from Himachal Pradesh and Uttar Pradesh respectively, of North West Himalaya. A new subgenus *Indotetraneura* under *Tetraneura* Hartig, has been erected to accommodate *Tetraneura basui* Hille Ris Lambers, *Tetraneura javensis* van der Goot and *Tetraneura lambersi* sp. nov. *Thecabius affinis* (Kaltenbach) is reported here for the first time from India. Besides, 2 other species of *Tetraneura* have also been reported from the roots of grass from the area of study.

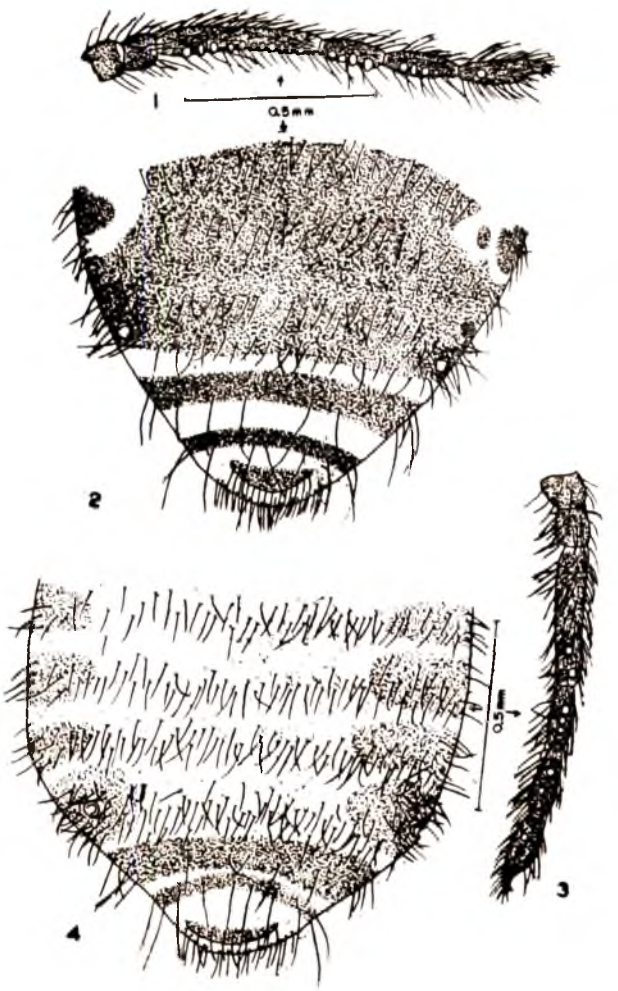
(*Key words :* **Insects, root aphids, taxonomy, morphology, new species, India**)

In recent times, a good number of aphid species have been reported from North West Himalayan part of India. Most of these species were reported to infest the aerial parts of their host plants. However, 7 species, viz., *Eriosoma lanigerum* (Hausman), *Forda* (*Pentaphis*) *orientalis* George (David, 1969), *Prociphilus taxus* (Ghosh *et al.*= *Anocaudus taxus* Ghosh, A. K., *et al.* 1969), *Prociphilus* (*Stagona*) *himalayaensis* Chakrabarti (1976), *Protrama longitarsus sclerodensus* Kumar (1973), *Protrama penecaeca* Stroyan (Verma and Mathur, 1966) and *Rhopalosiphum rufiabdominalis* (Sasaki) (Ghosh, L. K. 1969) are so far known to infest roots of the host plant in North West India.

During the collection of aphids from North West Himalayan part of India, special emphasis has been given in recent times on the root inhabiting species and as a result many samples of aphids have been discovered. Out of these root inhabiting aphids so far identified, 2 species viz., *Anoecia himalayensis* and *Tetraneura* (*Indotetraneura*) *lambersi* are new to science and *Thecabius affinis* (Kaltenbach) is new to India. A new subgenus *Indotetraneura* has been erected with *Tetraneura javensis* van der Goot as the type species. The other members included in this new subgenus are *Tetraneura basui* Hille Ris Lambers and *Tetraneura lambersi*, sp. nov. Besides, two other species have been recorded to infest the roots of grass in the area of study. Details of these species have been included in this paper.

1. Anoecia himalayensis, sp. nov. (Figs. 1–4)

Alate viviparous female : Body about 2.05–2.07 mm long with 0.99–1.06 mm as maximum width. Head blackish brown; dorsal cephalic hairs numerous, long and fine, longest hair on vertex about 69–72μ long and 2.6–3.3 times the basal diameter of antennal segment III. Antennae (Fig.1) about 0.50–0.55 times of body; segment I with 7 hairs about 52–55 μ long; segment II with 17 hairs about 58–69μ long; flagellum brown, smooth except segment VI which is imbricated, segment III with 46, IV with 27, V



Figs. 1& 4. *Anoecia himalayensis* sp. nov. Alate viviparous female : 1. antennal segments; 2. posterior portion of abdomen; apterous viviparous female : 3. antennal segments; 4. posterior portion of abdomen.

with 25 and VI with 27 hairs besides the apical 3 hairs; processus terminalis about 0.37–0.44 times the base of the segment VI; segment III with 12–14, IV with 3–4, V with 4–5 and VI with 0–1 secondary rhinaria arranged in a row on the outer margin of the segment; hairs on flagellum long and fine, longest on the segment III about 65–83μ long and 3.0–3.1 times the basal diameter of the segment. Ultimate rostral segment reaching midcoxae, about 0.67–0.78 times the second joint of hindtarsus and bearing 4 pairs of accessory hairs. Thorax brown to blackish brown, much hairy. Abdomen (Fig.2) pale brown, wrinkled particularly on sclerotic patches; tergites 3–6 fused; dorsum with brown central patch on tergites 3–6 and transverse bands on 7 and 8; marginal patches distinct on all tergites; spiracles on dark sclerites; dorasl hairs mostly with flagellate

apices, segment 1 with 16, 2 with 34, 3 with 40–45, 4 with 32–41, 5 with 26–30, 6 with 16–21, 7 with 12 and 8 with 10 hairs including marginals, longest hair on anterior tergites about 76–86 μ long and 3.1–3.6 times the basal diameter of antennal segment III, on 7th about 83–90 μ long and 3.2–4.0 times and on 8th about 107–121 μ long and 4.3–5.1 times the mentioned diameter, respectively. Siphunculi dark brown, surrounded by nearly 21 hairs. Venter smooth, ventral hairs numerous similar or slightly longer than the dorsal hairs. Cauda oval bearing 14 hairs. Subanal plate semicircular with about 10 hairs. Subgenital plate with 18 short hairs. Legs dark brown, much hairy, longest hair on femora about 58–72 μ long and of hindtibia about 79–93 μ long and 3.37–3.83 times the basal diameter of antennal segment III and 1.42–1.53 times the middle diameter of tibiae; claw 1.23–1.25 times the empodium; first tarsal segments with 7 hairs. Wings scaly specially apically, veins pale; forewing with media once branched and separate from the pterostigma, pterostigma much broadened apically, radial sector distinctly curved; hindwing with both the obliques.

Measurement in holotype in mm : Length of body 2.05, width 1.06; antennal segments III:IV:V:VI 0.39:0.16:0.18:0.14 + 0.06; ultimate rostral segment 0.64, second joint of hindtarsus 0.96.

Apterous viviparous female : Body about 1.97 mm long with 1.12 mm as maximum width. Head dark brown, smooth, dorsal cephalic hairs numerous (at least 18 pairs) with flagellate apices, longest one on vertex about 86 μ long and 2.6 times the basal diameter of antennal segment III. Antennae (Fig. 3) with segments I and II dark brown; wrinkled; processus terminalis about 0.33 times the base of segment VI; secondary rhinaria oval to round and non-ciliated, segment III with 4, IV with 3–4, V with 2 and segment VI with 0–1 secondary rhinaria; hairs on antennal segment III with 39, IV with 19, V with 26 and segment VI with 28 hairs, longest one on segment III about 62 μ long and 1.8 times the basal diameter of the segment. Ultimate rostral segment dark, about 0.41 times the second joint of hindtarsus. Abdomen (Fig. 4) smooth, brown excepting the marginal intersegmental sclerites which are pale, each of segment 7 and 8 with brown semicircular transverse band, dorsal hairs numerous with fine apices, each of anterior tergites with numerous hairs (at least 50–71 hairs), longest spinal hair on anterior tergites about 2.5 times the basal diameter of antennal segment III, 7th tergite bears 14 hairs, about 72 μ long and 2.1 times, 8th tergite bears 9 long hairs with flagellate apices, about 79 μ long and 2.3 times the mentioned diameter, respectively. Siphunculi ring like with chitinised rim placed on chitinous sclerite surrounded by about 25 hairs. Cauda semioval with 8 hairs. Legs brown, smooth; femoral hairs numerous, long and fine; hindtibial hairs about 72 μ long and 2.1 times the basal diameter of antennal segment III and equal to the middle diameter of tibiae; other characters as in alate viviparous females.

Measurements of one specimen in mm: Length of body 1.79, width 1.12; antennal segments III:IV:V:VI 0.34:0.16:0.16:0.14 + 0.04; ultimate rostral segment 0.38; second joint of hindtarsus 0.91.

Holotype : Alate viviparous female, INDIA : HIMACHAL PRADESH: Simla, 26.xi. 1972 from unidentified grass root (Graminae) (coll. S. Chakrabarti). **Paratypes** : 1 apterous viviparous female and many nymphs, collection data as in the holotype; 1 alate viviparous female, INDIA : UTTAR PRADESH: Kousani, 26.v.1969 from *Petunia violaceae* (Vagrant) coll. S. Chakrabarti.

Remarks : *Anoecia himalayensis*, sp. nov. in having dorsal sclerotisation in alatae comes to *Anoecia* s.s. Zwolfer (1957) gave a key to Anoeciinae and Stroyan (1964) provided a translated version of the above key. Following the above key, *himalayensis* sp. nov., comes close to *Anoecia corni* group (A. *coni* Fabricius, *A. disculigera* Borner, *A. hanpti* Borner and *A. major* Borner). But *himalayensis* sp. nov., can be differentiated from *disculigera*, *haupti* and *major* in having secondary rhinaria in apterae and from *corni* in the absence of spatulate hairs on tergites 5-7 besides other characters. Recently Pal and Raychaudhuri (1977) described *Anoecia radiciphaga* from North East India. The present new species differs from *radiciphaga* Pal and Raychaudhuri in having shorter hairs on dorsum of head and on anterior abdominal tergites (4.75-5.56 times and 4.0-4.9 times the basal diameter of antennal segment III, respectively in *radiciphaga*) and more secondary rhinaria on antennal segment III (6-9 in *A. radici-*

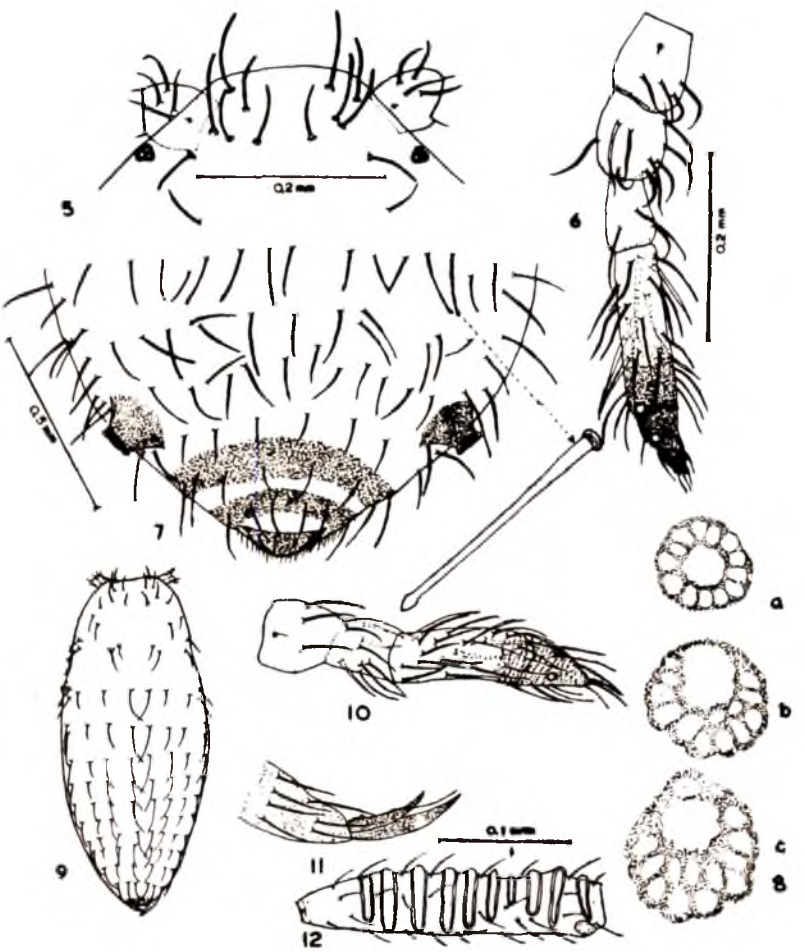


Fig. 5 – 11. *Tetraneura* (*Indotetraneura*) *lambersi*, sp. nov. Apterous viviparous female : 5. Head; 6. antennal segments; 7. posterior portion of abdomen; 8. (a,b,c). wax plates; Embryo: 9. dorsum of body; 10. antennal segments; 11. claw; alate viviparous female : 12. third antennal segment.

phaga). Besides Pal and Raychaudhuri (*op. cit*) also redescribed *Anoecia vagans* (Koch) from the same area. The present new species also differ from *vagans* in having abdominal sclerotisation in alate viviparae and shorter hairs on antennal segment III, short ultimate rostral segment in comparison to second segment of hindtarsus, without wax plates, and fan shaped to incrassate apices of hairs on abdomen in apterae.

Indotetraneura nov. subgen.

Hille Ris Lambers (1970) in his excellent work on *Tetraneura* Hartig erected a new subgenus *Tetraneurella* and differentiated it from *Tetraneura s.s.* in having long hind-claws which are at least 0.06 mm long and distinctly longer than the midtarsal claws and at least as long as, and usually longer than the tarsal joint on which they are attached in the first instar nymphs. Recent investigations and also from the detailed work on *Tetraneura* Hartig by Hille Ris Lambers (1970) it is clearly evident that there exists a group of *Tetraneura* where the claws are distinctly unequal in the embryos and first instar nymphs and this prompted to erect a new subgenus *Indotetraneura* with *Tetraneura javensis* van der Goot as the type species. The other members of this new subgenus so far, are *Tetraneura basui* Hille Ris Lambers (1970) and *Tetraneura lambersi* sp. nov.

The new subgenus *Indotetraneura* thus differs from *Tetraneura s.s.* and *Tetraneurella* Hille Ris Lambers in having distinctly unequal claws at least in the hindlegs of embryos and first instar nymphs.

Type species : *Tetraneura javensis* van der Goot.

Distribution: India, Pakistan, Java, Formosa.

2. **Tetraneura (Indotetraneura) lambersi** sp. nov. (Figs. 5-12)

Apterous viviparous female : Body globular, about 1.61-1.75 mm long. Head (Fig. 5) brown, dorsum distinctly rugose, sometimes with a pair of wax plate, dorsum with 7 pairs of long and short hairs, longest hair on vertex about 69-90 μ and shortest one about 45-52 μ long and 2.10-3.12 times and 1.40-1.87 times the basal diameter of antennal segment III, respectively. Antennae (Fig. 6) 5-segmented (in one specimen 6-segmented), brown except the apices of segment IV and whole of segment V, smooth except segment V which is imbricated, about 0.24-0.30 times the body ; antennal segment I with 3-5 long and stout hairs of about 41-52 μ long and one minute hair of about 6 μ long ; segment II with 9–13 hairs of about 45-55 μ long, segment III with 3-6 hair and longest one about 38-55 μ long and 1.8–2.0 times times the basal diameter of the segment; segment IV with 21-27 hairs, last antennal segment indistinctly separated from segment IV and with 3-4 hairs besides the apical hairs ; primary rhinaria strongly ciliated. Eyes 3-faceted (13-17 facets present in two specimens). Ultimate rostral segment dark apically, about 1.43-1.57 times the second segment of hindtarsus and about 0.11-0.13 mm long and with rows of longitudinal spinules and with 3-5 pairs (mostly 3 pairs) of accessory hairs. Thorax marginally with 3 pairs (rarely 2 pairs) of long and stout hairs, longest one on metathorax c^c about 166-194 μ long ; midthoracic furca with separate arms. Abdomen (Fig. 7) smooth, pale brown and with brown transverse bands on each of the segment 7 and 8 ; segmentation indistinct upto segment 6; dorsal hairs long and stout with acuminate, blunt, fan-shaped or with furcated apices arranged more or less segmentally, each of anterior abdominal tergite with 15-20 hairs including 3 pairs of marginals which are longer than other hairs, gradually become shorter caudad, longest marginal hair 163–218 μ and shortest one 65-90 μ long, longest

pleural and spinal hairs on anterior tergites about 117-163μ long and 138-178μ long, and 3.77-5.87 times and 4.0-6.0 times respectively, the basal diameter of antennal segment III; 7th tergite with 8 hairs, about 83-104μ long and 2.40-3.37 times the basal diameter of antennal segment III; 8th tergite with 6 hairs, about 90.-104μ long and 2.70-3.75 times the mentioned diameter. Venter of abdomen with rows of spinules; ventral hairs numerous, short and fine, arranged segmentally. Siphunculi brown to dark brown with chitinised rims, about 8-9 mm long and 18-19 mm as maximum width. Cauda dark brown bearing 4 hairs. Subanal plate semicircular with 8 hairs including 2 long hairs. Subgenital plate forming 2 circular lobes each bearing 9-12 hairs. Legs pale brown to dark brown, smooth; hindfemora and tibiae about 0.009–0.011 mm and 0.006–0.008 mm thick medially; hairs on tibiae about 41-52μ long; claw 0.04 mm long and 0.92-0.93 times the empodium. Wax plates (Fig. 8a, b,c) present both dorsally and ventrally, ventral wax plates (52.02-63.58 μ diameter) with a large eccentric central cell and with 5-16 smaller cells arranged in single tier or in two tiers, each of thoracic and abdominal segments with a pair of spinal and pleural wax plates, cells on wax plates are higher on mesothorax, metathorax and anterior abdominal tegites and lowest on abdominal tergites 6 or 7, large and small cells in wax plates are about 17.3-23.1μ and 8.6-17.3μ in diameter respectively.

Measurements of holotype in mm: Length of body 1.61, width 1.24; antennal segmentsI. : II :III :IV ::V 0.08 : 0.06: 0.08: 0.14 : 0.03 + 0.03; ultimate rostral segment 0.53; second joint of hindtarsus 0.36.

Alate viviparous female : Body about 1.72-1.94 mm long . Head dark brown : dorsal cephalic hairs with flagellate apices, longest one about 34.41μ long and 1.66-2.40 times the basal diameter of antennal segment III. Antennae (Fig. 12) 6-segmented, darker than apterae, last antennal segments with rows of spinules; about 0.30-0.34 times the body; flagellar hairs long with flagellate apices, longest one on segment III about 20-24μ long and 1.16-1.40 times the basal diameter of the segment; segment III with 7-12, IV with 1-2 and V with 4-7 secondary rhinaria; processus terminalis 0. 33-0.5 times the base of the last antennal segment. Eyes multifaceted with distinct triommatidia. Ultimate rostral segment about 0.68-0.72 times the second joint of hindtarsus. Abdomen with brown transverse band on tergite 8, dorsal abdominal hairs long, longest hair on anterior abdominal tergite about 41-48μ long and 2.0-2-80 times the basal diameter of antennal segment III, longest hair on 7th and 8th tergites about 58-65μ and 69–86μ long and 2.83–3.80 times and 3.33-5.0 times the mentioned diameter, respectively. Sub-genital plate with many (24-28) hairs. Legs brown, tibiae with long and fine hairs. Wing vein pale, media one branched. Other characters as in apterous viviparous females.

Measurements of one specimen in mm : Length of body 1.92, width 1.04; antennal segments I :II :III : IV : V : VI 0.04 : 0.06: 0.21 : 0.06 : 0.18 : 0.04 + 0.01; ultimate rostral segment 0.49; second joint of hindtarsus 0.71.

Embryo (Figs. 9-11) : Antennae (Fig. 10) 4-segmented with long and pointed hairs about 46.2μ long; segment I with 3 long hairs and one very short hair; segment II with 8 hairs, III with about 20 hairs and IV with 7 hairs besides the apical hairs. Rostrum with rows of spinules; ultimate rostral segment about 124.2μ long and with 4 hairs. Hairs on dorsum (Fig. 9) long and

short. Thorax with 2-3 pairs of marginal 1 pair of pleural and spinal hairs : abdominal tergites 1-6 each with 2 pairs of marginal (inner one shorter), 1 pair pleural and 1 pair spinal hairs, longest spinal hair on anterior tergites about 98.3 μ long, pleural hairs about 57.8 μ long; 7th tergite with 6 hairs about 80.9 μ long, 8th tergite with 6 hairs about 115.6 μ long. Wax plates (about 8.7-26 in diameter) present venterolaterally, consisting of a central large cell (5.8-17.3 μ in diameter) surrounded by 4-14 very small cell (1.2-4.3 μ in diameter). Tarsi spinulose, claws (Fig. 11) unequal., longest one about 92.4-98.2 μ long and shortest one about 52.1-55.6 μ long, longest claw about equal to empodium.

Holotype : Apterous viviparous female, INDIA : UTTAR PRADESH : Mussoorie, 22. vi.1976 from unidentified grass root (Graminae) (coll. S.P. Maity). **Paratypes** : 21 apterous viviparous, 3 alate viviparous females and many nymphs, collection data as in the holotype.

Remarks : *Tetraneura* (*Indotetraneura*) *lambersi* sp. nov. in having long and unequal claws comes close to *Tetraneura* (*Indotetraneura*) *javensis* van der Goot (1917) but the former differs from the latter in having longer spinal and pleural hairs (0.052 mm in *javensis*), fewer small cells on ventrolateral glands (20-40 in *javensis*) and fewer hairs on subanal plate (10-14 in *javensis*). The embryos of *lambersi* sp. nov.. taken from apterous exules also differ from those of *javensis* in having fewer hairs on antennal segments I and II (8 hairs and 10 hairs respectively in *javensis*) and fewer marginal hairs on abdominal tergites 1-5 (4-6 in *javensis*).

The species is named in honour of Dr. D. Hille Ris Lambers, Bennekom, The Netherlands, for his constant inspiration in our aphidological studies.

3. *Tetraneura* (*Tetraneurella*) *nigriabdominalis* (Sasaki)

Specimen examined : 6 apterous viviparous females and 6 nymphs, INDIA : UTTAR PRADESH : Dehradun, Sahashradhara 12. x. 1976 from roots of *Setaria glauca* (Graminae) (coll. S.P. Maity) ; 25 apterous viviparous females and many nymphs, Uttar pradesh : Dehradun, New Forest, 13.x. 1976 from roots of *Setaria intermedia* and *Eleusine indica* (Graminae) (coll. S.P. Maity).

4. **Tetraneura radicicola** Strand

Specimen examind : 1 apterous viviparous female, INDIA : UTTAR PRADESH : Dehradun New Forest, 18.vi.1975 from unidentified grass root (Graminae) coll. S. Chakrabarti; 4 apterous vivparous females and 1 nymph Uttar Pradesh : Dehradun, New Forest, 13.x.1976 from *Imperata* sp. (coll. S. P. Maity).

5. **Thecabius affinis** (Kaltenbach)

Specimen examind : 8 apterous viviparous females and 5 nymphs, INDIA : HIMACHAL PRADESH : Manali, 31.xii.1972 from roots of ? *Geranium* sp. (coll.S. Chakrabarti).

Remarks : This species is recorded for the first time from India.

All the materials (including type materials mentioned in this paper are deposited at present in the collection of Entomology Laboratory, Department of Zoology, University of Kalyani except 1 paratype (alate viviparous female) which is with Entomology Laboratory, Department of Zoology, University of Calcutta.

Acknowledgements :– The authors express their thanks to Dr. D. Hille Ris Lambers, Bennekom, The Netherlands for comments on *Thecabius affinis* (Kaltenbach), to the Head, Department of Zoology, University of Kalyani for laboratory facilities. One of the authors (SPM) is also thankful to the University of Kalyani for granting him a Junior Research Fellowship for this study.

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THREE UNKNOWN FEMALES OF CRICKETS (ORTHOPTERA : GRYLLIDAE) FROM NORTH EAST INDIA WITH NOTES OF THEIR DISTRIBUTION

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(Received 30 September 1977)

The distinctive characters of the hitherto unknown females of three species, viz., *Stephoblemmus humbertiellus* Saussure, *Velarifictorus jaintianus* Biswas & Ghosh and *V. khasiensis* Vasanth & Ghosh, are described, along with notes on their distribution.

(*Key words : S. humbertiellus*; *V. jaintianus*; *V. khasiensis*)

A review of the literature shows that the following three species, viz., *Stephoblemmus humbertiellus* Saussure, 1877, *Velarifictorus jaintianus* Biswas & Ghosh, 1975 and *V. khasiensis* Vasanth & Ghosh, 1975 are known only from males. The present account deals with the distinctive characters of the hitherto unknown females of the above three species with notes on their distribution.

Materials of these species are deposited in the Eastern Regional Station, Zoological Survey of India, Shillong.

1. **Stephoblemmus humbertiellus** Saussure

Female :

General colouration black (in one specimen body is much darker than legs).

Head shining; occiput slightly pubescent, its width slightly narrower to slightly wider than pronotum. Frontal rostrum about two and a half times as wide as first antennal segment; no process on frontal rostrum as in male. Face flattened, slightly concave in profile in the region of clypeofrontal suture.

Tegmina short, extending only upto middle or end of 3rd abdominal tergite; dorsal field usually black, sometimes rufous brown, a slightly paler humeral band present in some specimens. Venation of dorsal field very variable, but usually presenting 3 oblique veins of which the most external one has a branch arising halfway to apex, or almost at base; discoidal unbranched or 1-branched. Numerous transverse connecting veinlets form irregular and shapeless areolae. Lateral field black, shining, with 3, more or less curved, somewhat parallel veins, of which the superiormost one may be a bit separate from others; mediastinal unbranched.

Ovipositor short, straight, slender, with apical valves sharply pointed, scarcely wide than stem.

Measurements in mm: Length of body: 8.50–10.00; length of pronotum: 1.80–2.50; width of pronotum: 2.00–3.00; length of tegmina: 2.00–3.00; length of posterior femora: 5.50–7.00; length of posterior tibia: 4.00–5.00; length of ovipositor: 4.70–5.50.

Material examined: 3 ♀ ♀. INDIA: MEGHALAYA: Khasi Hills dt.: Shillong: Risa Colony, 4. vi. 1975, 15. vi. 1975, 10. vii. 1975, R. Mathew ; 3 ♀ ♀, Shillong : Motinagar 14.vi. 1976, M.S. Jyrwa ; 1 ♀, Shillong: Lumparing, 19.v. 1975, M. S. Jyrwa; 6 ♀ ♀,

Upper Shillong, 1800 m, 6.vi.1947, M. Vasanth; 1 ♀, Umuiuh, 1175 m, 3. vi. 1971, G.M. Yazdani.

Remark : Only two specimens of this species have been found since Saussure's (1877) description, viz., Sandrasagra (1954) and Bhowmik (1969). Bhowmik (op. cit) reported the species for the first time from India (Uttar Pradesh). The present author feels that the species may not be so uncommon in the vicinity of Shillong, especially in the month of June when most of the specimens have been collected. The species is recorded for the first time from North east India.

2. Velarifictorus jaintianus Biswas & Ghosh

Female :

Size variable; general colouration dark brown to almost black.

Head very dark brown. A transverse yellow band connects lateral ocelli. Face not prominent as in male, showing no special elongation or concavity.

Tegmina usually short, extending upto hind margin of 3rd abdominal tergite (only in 2 specimens extending almost upto apex of abdomen); dorsal field brownish black with a yellow humeral band. Venation of dorsal field very variable, with 3–5 free oblique veins and with usually 3 branches of discoidal, rarely 4. Of the free veins, first and second inner ones may be branched; in most specimens a reticulation formed of both elongated and squarish areolae present. Lateral field with 4–6 free veins of which the first two or three are separated from the last ones by a space. Mediastinal with 1–3 branches. Interconnecting veinlets greater in number in posterior half. In the two specimens with longer tegmina, dorsal field presents 4–5 long oblique veins, and 4–5 branches of discoidal.

Wings do not extend beyond tegmina.

Ovipositor thin, with apical valves pointed scarcely wider than stem.

Measurements in mm: Length of body: 11.50–18.00; length of pronotum: 2.50–3.80; width of pronotum: 3.50–5.70; length of tegmina: 3.00–6.50 (10.00 in the two specimens with longer tegmina); length of posterior femora: 9.00–13.00; length of posterior tibia: 6.00–9.00; length of ovipositor: 8.00–14.00.

Material examined : 15 ♀ ♀, INDIA: MEGHALAYA: Khasi Hills dt. : Shillong, 1600m, 23.vi. 1975, 3.vii. 1975, 19.vi. 1975, 19.v. 1975, 14.vi.1976, 25.vi. 1975, 31.vi.1976, 19.viii. 1976, 8.vii. 1976, M.S. Jyrwa; 4 ♀ ♀. Shillong, 1600m, 18.viii.1974, 24.iv.1974, 28.iv. 1974, 2.viii.1976, M. Vasanth; 4 ♀ ♀, Shillong, 1600 m, 28.vii. 1975, 31.v. 1975, 11.vi. 1975, 13.vi.1975, R. Mathew; 3 ♀ ♀, Shillong, 1600 m, 27. vi. 1972, 23.ix. 1971, 3.vii. 1975, R.S. Giri; 1 ♀, Shillong, 1600 m, 21.v. 1974, K.Deb; 1 ♀, Shillong, 1600 m, 11. v.1973, J.K. Prasad; 4 ♀ ♀, Old Barapani Road, 1400 m, 6.vi. 1973, A.K. Ghosh, 1 ♀, Barapani, 1175 m, 15.v. 1971, R.S. Pillai; 1 ♀, Barapani, 1175 m, 22.vi. 1976, M. Vasanth ; 1 ♀, Mawphalang, 1850m, 15.vii. 1963, V. D. Srivastava; 1 ♀, Mawphalang, 1850 m, 22. viii. 1963, S. Biswas; 1 ♀. Umtham, 870 m, 25. vii. 1972, A.K. Ghosh; 1 ♀, INDIA: Meghalaya: Garo Hills dt. : Arivila Forest, 5.iii. 1975, S. Biswas, 1 ♀, Rongrengiri, 340 m, 19. iv. 1973, S. Biswas; 1 ♀, Darugiri Forest, 13.iv. 1971, R.S. Pillai; 5 ♀ ♀, India: Meghalaya: Jaintia Hills dt. : Garampani Forest, 500 m, 15.xii. 1972, S.K. Chanda; 2 ♀ ♀, Garampani Forest, 500 m, 13.xii. 1975, S.K. Chanda; 1 ♀, Thadlaskein, 1460 m, 17.vi. 1872, S. Biswas; 1 ♂, India: Assam: Sibsagar dt. : Kaziranga National Park, 21.ii.1974, M. Datta; 1 ♂, India: Assam: Darrang dt. : Sonai Rupai Forest (Foot Hills area), 150 m, 7. xi. 1975, K.R. Rao & party.

Remark : The females of this species can be distinguished from those of *V. grylloides* (Chopard) to which they are akin, by the somewhat shorter tegmina and by the veins of the lateral field of tegmina which are separated into 2 groups by a space.

Previously known only from the khasi Hills and Jaintia Hills districts of Meghalaya, this species is here recorded for the first time from the Garo Hills district of that State. It appears common in the State during monsoon months. Vasanth (1977) has described the mating behaviour of this species. It is also reported for the first time from Assam.

3. Velarifictorus khasiensis Vasanth & Ghosh

Female :

Size small to medium.

Head : No transverse band between lateral ocelli. Frontal rostrum about twice as wide as first antennal segment. Mandibles normal.

Tegmina extending only upto end of 4th abdominal tergite, its internal margin and apex slightly rounded. Dorsal field dark brown to rufous brown with a more or less conspicuous yellow humeral band. Venation irregular and somewhat confused, with usually 4 (rarely 6) oblique veins, and many transverse veinlets which give rise to an irregular reticulation, although in some specimens it is possible to discern some elongated areolae in anterior part and some squarish ones in posterior part. Branches of discoidal not clear, from none to 3. In some specimens even the tegmina of the two sides show different number of branches. Lateral field either yellow with dark brown dorsal band, or with posterior portion also dark brown, or wholly dark brown, presenting 4–5 regular and parallel veins; mediastinal with 1–2 branches, which may be, arranged differently in different specimens anteriorly in some posteriorly in others.

Wings do not extend beyond tegmina.

Ovipositor with apical valves pointed, only slightly wider than stem.

Measurements in mm: Length of body: 10.20–13.50; length of pronotum: 2.50–3.00 ; width of pronotum : 3.70-4.70 ; length of tegmina : 4.00-5.30 ; length of posterior femora ; 8.00-9.50 ; length of posterior tibia : 5.00-6.00 ; lentgth of ovipositor : 9.00-10.20.

Material examind: 2 ♀ ♀, INDIA: MEGHALAYA : Khasi Hills dt. : Umtham, 870 m, 21.iv.1964, A.K. Mandal ; 2 ♀ ♀ : Mawblang 1100 m, 31.iii 1971, R.S. Pillai ; 2 ♀ ♀ Mylliem, 1825 m, 21.iv.1973, R.S. Pillai; 1 ♀, Barapani, 11 75 m, 22.vi. 1976, M. Vasanth ; 1 ♀, Umniuh, 1175 m, 3. vi. 1971, G.M. Yazdani ; 1 ♀, Mawlyndep, 3.vi.1971, G.M. Yazdani ; 1 ♀, Upper Shillong, 1800 m, 27.viii.1975, M.S. Jyrwa & K.Deb.

Remark : The females of this species are similar to those of V. *bilobatus* Bhowmik and V. *fallax* (Chopard) but can be distinguished from the last two by the longer tegmina and ovipositor.

Unlike the males which have been recorded from the Garo Hills and Khasi Hills districts of Meghalaya (Vasanth et. al., 1975) the females have been collected only from the Khasi Hills district of that State.

KEY TO THE FEMALES OF THE INDIAN SPECIES OF *VELARIFICTORUS* RANDELL.

1. Lateral ocelli connected by a transverse yellow band 2
—Lateral ocelli not connected by a transverse yellow band 8

2. Tegmina extending almost upto extremity of abdomen 3
—Tegmina extending upto about middle of abdomen or shorter 5

3. Only first 3 veins of dorsal field of tegmina somewhat clear, others distinguishable only apicad ..... *andamanensis* Bhowmik
—All veins of dorsal field of tegmina clear 4

4. Veins of dorsal field of tegmina feebly oblique, reticulation not so close and long ..... *aspersus* (Walker)
—Veins of dorsal field of tegmina almost straight, close to one another, reticulation closer and longer ..... *maindroni* (Chopard)

5. Dorsal field with yellow humeral band 6
—Dorsal field without yellow humeral band 7

6. Tegmina longer; veins of lateral field somewhat distant ..... *grylloides* (Chopard)
—Tegmina shorter; veins of lateral field in 2 groups separated by a space ..... *jaintianus* Biswas & Ghosh

7. Tegmina extending to middle of abdomen .. .. *ceylonicus* (Chopard)
—Tegmina scarcely extending to middle of abdomen ..... *parvus* (Chopard)

8. Tegmina extending upto apex of 2nd abdominal tergite; ovipositor shorter 9
—Tegmina extending upto apex of 4th abdominal tergite; ovipositor longer ..... *khasiensis* Vasanth & Ghosh

9. Apex of tegmina truncated; ovipositor short (2.25mm) ..... *bilobatus* Bhowmik
—Apex of tegmina rounded; ovipositor longer (6.50mm) ..... *fallax* (Chopard)

Acknowledgements :– I am grateful to the Director, Zoological Survey of India, Calcutta, for providing me opportunity to undertake this work, and to Dr. H. Khajuria, Officer-in-Charge, Eastern Regional Station, Zoological Survey of India, Shillong for providing working facilities. I wish to thank Dr. A. K. Ghosh of the same institution, for his guidance and sustained encouragement during the study.

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A NEW SPECIES OF *BRACHYCROTAPHUS* KRAUSS (ORTHOPTERA : ACRIDIDAE : TRUXALINAE) FROM NORTH WEST INDIA

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(*Received 6 September 1977*)

A new species of the genus *Brachycrotaphus* has been described from north west India and it has been suggested that this genus may be widely distributed throughout the plains of India.

(*Key words* :– **new acridid)**

Genus *Brachycrotaphus* Krauss, is represented by a single species – *B. longiceps* (Bolivar) in India. It has been recorded from Madurai and Dohnavur in Tamil Nadu. Second species of this genus from India has been recorded from District Hoshiarpur in Punjab and is being described here as new. Wide gap in the distribution of these two Indian species suggests that this genus may be widely distributed throughout the plains of India and not restricted to the southern tip as understood uptill now.

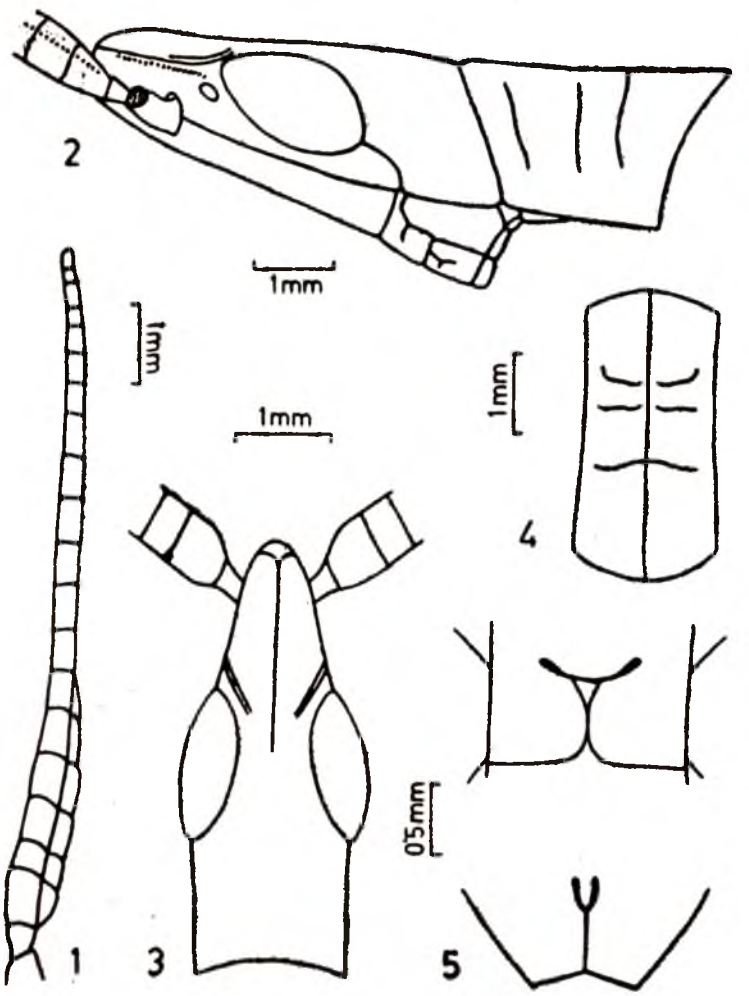
Brachycrotaphus hoshiarpurensis sp. novo

Holotype : Male INDIA, PUNJAB Dist. Hoshiarpur, Bankhandi, 12. ix. 1967, coll. Asket Singh.

Small, slender, comparatively smooth. Head (Figs. 2,3) longer than pronotum. Antennae (Fig. 1) ensiform, as long as head and pronotum together, first six segments markedly flattened. Fastigium of vertex as long as the eyes, slightly narrowing anteriorly and broadly rounded in front, tectiform, with well defined median and lateral carinae, median carina, obliterated over the vertex. Foveolae lateral, gradually narrowing in front, their lower carinae poorly developed. Face very oblique, frontal costa grooved, its lateral carinae gradually widening ventrally, lateral carinae arched, well developed. Eyes oval, space between the eyes approximately one half the width of fastigium.

Pronotum (Fig. 4) cylindrical, median carina visible throughout but weakly developed, cut by only one transverse sulcus, lateral carinae absent, principal sulcus placed well behind the middle, metazona slightly rugulose, rounded posteriorly; deflexed lobes trapezoidal, longer than high, their lower margins straight. Prosternum with a short pyramidal spine with a sharpely pointed tip. Mesosternal lobes (Fig. 5) squarish, contiguous in the middle. Metasternal lobes contiguous throughout.

Abdomen with a weakly developed median carina. Tympana large. Epiproct (Figs. 7&8) short, slightly broader than long, with a median and two lateral, obliquely placed sulci, all converging together near the tip which is acutely pointed. Cerci longer than epiproct, their tips directed medially and acutely pointed. Subgenital plate truncated posteriorly. Male genitalia typically truxaline, epiphallus with bridge wide, lophi well developed, ancorae with anterior ends directed outwards, anterior projections with

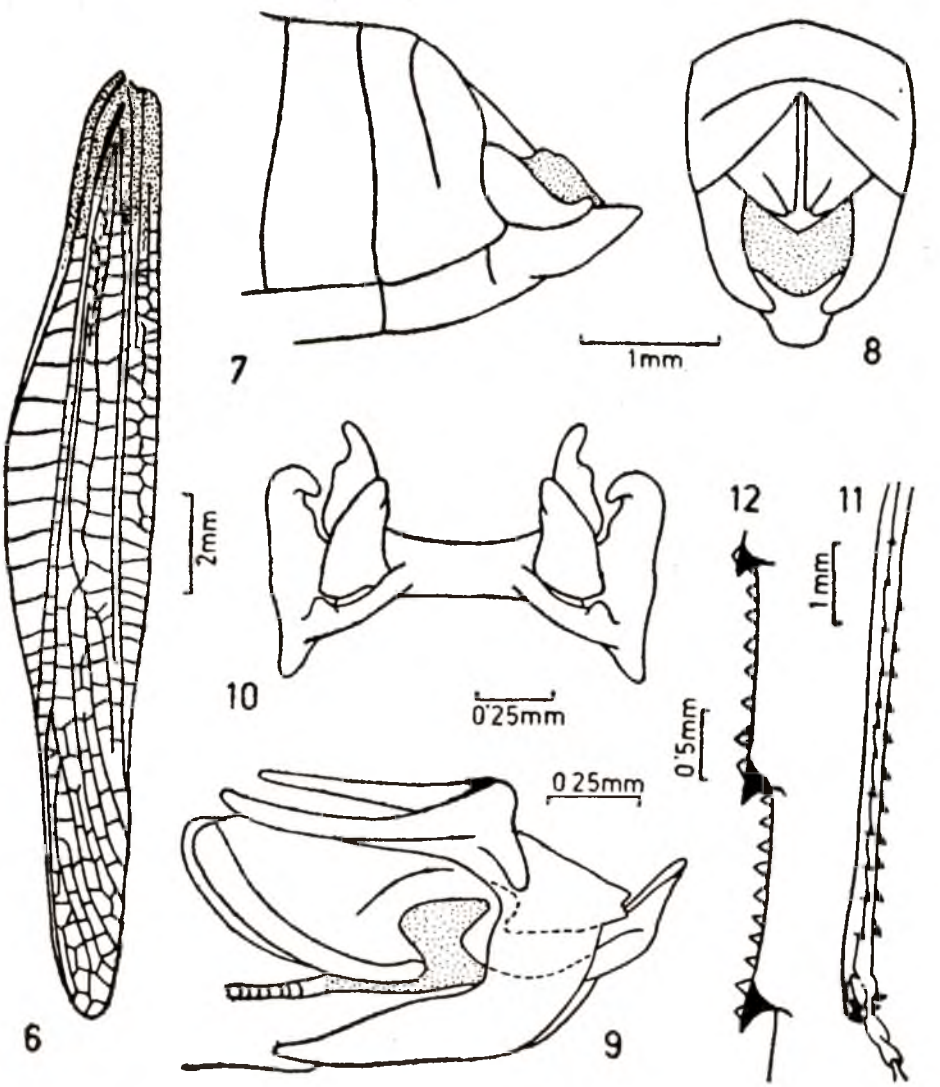


Figs. 1–5. *Brachycrotaphus hoshiarpurensis* sp. n. Male: 1–Right antenna; 2–Head and pronotum, side view; 3–Head, from above; 4–Pronotum, from above; 5– Meso- and metasternal lobes.

inwardly directed hooks, basal valves of penis very large, cingular valves absent.

Hindfemora long and slender, slightly shorter than abdomen, upper carina smooth, stridulatory pegs well marked, fairly large anteriorly, very fine in the middle and slightly larger near the posterior extremity. Hind-tibiae (Figs. 11, 12) without external apical spine, external spines simple, internal spines except for three or four basal ones gradually enlarged and with a series of well defined ridges on their outer aspect. Tegmina (Fig. 6) long and narrow, extend beyond tip of the abdomen, costal area very wide, with a series of transverse veins, median area slightly widened. Hindwings slightly shorter than tegmina.

General coloration uniformly light brown. Lower margin of the deflexed lobes of pronotum with a pale band which is continued



Figs. 6–12. *Brachycrotaphus hoshiarpurenis* sp. n. Male: 6–Left tegmen; 7 & 8–Abdominal terminalia; 9–Genitalia; 10–Ephiphallus; 11–Right hindtibia; 12–Internal spines of hindtibia showing ridges.

anteriorly over the head along ventral margin of compound eyes upto the base of antennae. Hindfemora and tibiae palish, spines of hindtibiae tipped with black, outer ridges of internal spines brown.

Measurements : Body, 21.0 mm; head, 4.5 mm; pronotum, 3.5 mm; tegmen 18.5 mm; hindfemur, 9.0 mm.

Allotype : Female. INDIA, PUNJAB Dt. Hoshiarpur, Manguwal, 1600′, 10. ix. 1967, Coll. Asket Singh.

Similar to the holotype but larger. Antennae broken. Tegmina with costal area not as much widened as in the holotype. Hindfemora with weakly developed stridulatory pegs. Spines of the hindtibiae simple,

without ridges. Epiproct simple, broadly rounded behind. Cerci shorter than epiproct.

Measurements : body, 29.0 mm; head, 6.0 mm; pronotum, 5.0 mm; tegmen, 24.5 mm; hind,femur, 12.0 mm.

Paratype : 2 males, same data as the holotype. 9 male and 6 females, same data as allotype.

All the paratypes are similar to the holo- and the allotypes described above but differ slightly in their measurements. Pale stripe on the sides of the head and the pronotum is poorly developed in most of them.

Measurements : Males–body, 19.0–23.0 mm.; head, 4.5 – 5.0 mm.; pronotum, 3.5 mm; tegmen, 16.5 – 18.5 mm; hindfemur, 12.0 mm. Females – body, 27.0 – 31.5 mm; head, 6.0 mm; pronotum, 4.5 – 5.0 mm; tegmen, 23.5 – 25.5 mm; hind femur, 12.0 mm.

The new species is very closely related to the other Indian species, *B. longiceps* (Bolivar) from which it differs in the following characters. It is smaller in size, fastigium of the vertex is not longer than eyes, head is less than one and half times the length of pronotum, and cerci are longer.

Holotype and all the paratypes are in the collections of Zoological Survey of India.

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A NEW SPECIES OF *MYRSIDEA* (PHTHIRAPTERA) ON *GARRULAX* (AVES) FROM NORTH EAST INDIA

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(Received 11 October 1977)

A new species *Myrsidea ananthakrishnani* **for specimens off the type host** *Garrulax phoeniceus bakeri* **(Hartert) from north east India has been described and illustrated.**

(*Key words :* **new** *Myrsidea*)

There are 13 species of *Myrsidea* Waterston, 1975 currently recognized by Tandan (1972) as occurring on Babblers of the genera *Garrulax* and *Pematorhynus* (Subfamily Timaliinae, Aves). Out of these thirteen species, 5 are with well developed hypopharynx and rest 8 species possess reduced hypopharynx as delimited by Tandan (1972). I recently collected 5 females and 5 males of *Myrsidea* from Assam Crimsonwinged laughing thrush [*Garrulax phoeniceus bakeri* (Hartert)] at Shillong. A study of these lice has shown them to represent an yet undescribed species of *Myrsidea* with reduced hypopharynx and it is my purpose to herewith describe and illustrate these *Myrsidea* under a new species *Myrsidea ananthakrishnani* in this paper. The host name is according to Ripley (1961). Morphological terminology and numbers applied to certain setae follow Clay (1969). Figures in parentheses denote the number of specimens or structures examined or measured, and *m* the mean. Measurements are in millimetres.

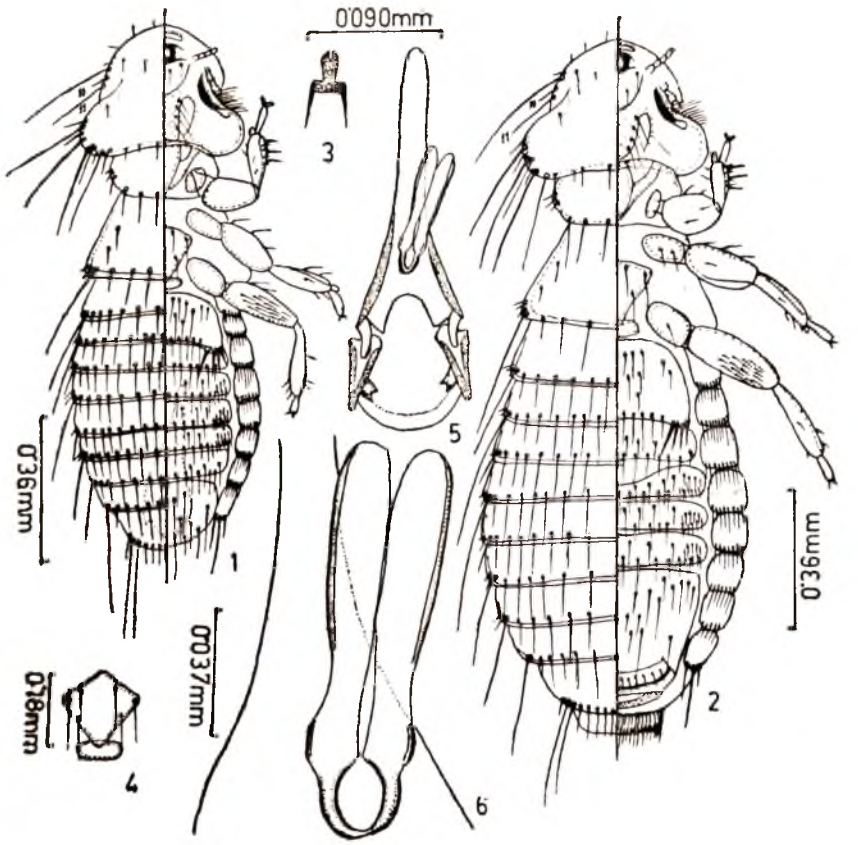
Type material for the new species are at present deposited at the Eastern Regional Station, Zoological Survey of India, Shillong and would be transferred to the National Zoological collection, Zoological Survey of India, Calcutta in due course.

Myrsidea ananthakrishnani Sp. nov. (Figs. 1–6)

Type host : *Garrulax phoeniceus bakeri* (Hartert)

Diagnosis : This species closely resembles *M. erythrocephali* Tandan, *M. thailandensis* Tandan, *M. singularis* Tandan and *M. sehri* Ansari and is distinguished from these in both sexes by the greatly reduced hypopharynx. Females of the new species may be separated from these species by the number of setae on tergum I, nature of sternum IV, tergum and sternum VII-IX and vulval margin. The males can be separated by the number of tergo-central setae on tergum I and by the details of male genitalia (Fig. 5), specially the genital sclerite (Fig. 6) which is distinctive from all the related species. In the following description, those characters which are common to all the species of *Myrsidea* infesting the aforesaid genera of the hosts and discussed by Tandan (1972) have not been included.

Male and *female :* Hypopharynx greatly reduced (Fig. 3). Head seta 10 is fine and short while 11 is longer and stouter (Figs.1 and 2). In the female, tergum I slightly enlarged and II normal. Sternum IV medially narrowed and sternum VII–IX are fused (Fig. 2). Vulval margin strongly



Figs. 1–6. *Myrsidea ananthakrishnani* sp. n. 1, Male. 2 Female. 3, Hypopharynx, female. 4, Metasternal plate, female. 5, Male genitalia. 6, Male genital sclerite (Orientation of structures as in preparation).

serrated. The stucture of spermathecal duct and bursa copulatrix remains unexplored as these structures are not visible in available material, for which effort must be made when further material is available for study. In the male genitalia (Fig. 5) the parameres are rather straight, anteriorly rounded and the inwardly directed arm of the basal apodeme is long and does not taper posteriorly (similar to *singularis*). Genital sclerite is characteristic (Fig. 6). Apex of metasternal plate slightly produced (Fig. 4). Metanotal setae : ♀, 6(4); ♂ 6 (4). Metapleural setae: ♀, 4–5 *m* 4.50 (10 sides); ♂, 3–4 *m* 3.35 (8 sides). Metasternal setae: ♀, 6 (3), 7(1); ♂ 6 (2). Outer dorsal setae of tibia I: ♀, 4 (8 tibiae); ♂, 4 (5 tibiae). Setae of femoral brushes : ♀ 14–19, *m* 16.50 (9 femora); ♂ 14–17, *m* 15.00 (7 femora).

Abdominal chaetotaxy : Tergal setae : ♀ (Fig. 2) (5) : I, 13–15, *m* 14.20; II, 16–18 *m* 17.00; III, 16–17, *m* 16.50; IV, 14–17, *m* 15.00; V, 14–15, *m* 14.50; VI, 13–15, *m* 14.00 VII, 10–12 *m* 11.20; II–VII, total, 100–105, *m* 102.50; VIII, 9–11, *m* 9.75; IX, 5+5 moderately long. ♂, (Fig.1) (4) : I, 12–13 *m* 12.75 II, 15–18, *m* 16.75; III, 15–16, *m* 15.25; IV, 14–17, *m* 14.75; V, 15–16, *m* 15.25; VI, 12–16, *m* 14.00; VII, 12–16, *m* 13.50; II–VII total,

TABLE 1. Central setae of sternites and lateral sternal brushes ♂ and ♀.

		Male				Female			
		Central setae of sternites		Setae of lateral sternal brushes		Central setae of sternites		Setae of lateral sternal brushes	
		Range	Mean (4)	Range	Mean (8 sides)	Range	Mean (4)	Range	Mean (8 sides)
III	Anterior	4–6	5.25	Nil	Nil	6–9	7.25	0–2	1.00
	Marginal	10–12	10.50	3–4	3.40	11–13	12.50	4–5	4.40
	Total	14–18	15.75	3–4	3.40	19–20	19.75	5–7	6.00
IV	Anterior	4–7	5.75	4–8	6.00	7–8	7.75	7–10	9.00
	Marginal	11–15	13.25	2–6	5.00	13–16	14.25	5–7	6.20
	Total	17–22	19.00	6–12	10.00	21–24	22.00	13–17	15.45
V	Anterior	5–8	7.00	4–8	6.50	8–9	8.50	8–12	10.35
	Marginal	11–14	12.75	4–6	5.20	10–15	12.50	6–8	7.00
	Total	18–22	19.75	8–14	12.25	19–24	21.00	14–19	17.40
VI	Anterior	7–9	7.75	3–6	5.00	7–9	8.00	5–9	7.00
	Marginal	11–15	13.25	3–4	3.50	10–12	11.50	3–6	5.50
	Total	18–23	21.00	7–10	8.50	17–21	19.50	10–14	12.20

86–98, *m* 89.50; VIII, 11–12. *m* 11.50; IX, terminal, 6(4), but the lateral very long and stout setae are 2+2 associated with 1+1 small setae lateral to them (Fig.1). In the males, the ends of the more central setae on tergum VIII fall short of the posterior margin of the IX but the setae lateral to them are shorter. In female, the two setae in central position just reach the posteror margin of IX and seta lateral to them are shorter. Pleural setae : Anterior setae absent (Figs. 1 & 2). VIII : ♂, no extra inner setae; ♀, extra inner setae present in some specimens : 0+1 (2); 0+0 (2);1+1 (1); In both sexes outer and inner setae as in (Figs. 1 & 2). Sternal setae; ♀; II, anterior 16–18, *m* 17(4), all central; marginal 10–15, *m* 11.75)(4); total of anterior and margnal 28–31, *m* 29.50 (4); aster, 4(15 asters); sternites III–VI and lateral sternal brushes, Table–1; sternites VII–IX fused with total setae 29–32, *m* 30.50 (4); vulval margin 11–13, *m* 12(5). ♂, II, anterior 14(2), marginal 10–11 (2); total of anterior and marginal 24–25, *m* 24.50 (2); III–VI and lateral sternal brushes, Table–1 VII, anterior 8–10, *m* 8.50 (4); marginal 15–16, *m* 15.25 (4), total of anterior and marginal 23–25, *m* 24.00 (4); genital region : 23–25, *m* 24.00 (4).

Measurements : Length : total ♀ 1.60–1.69, *m* 1.64 (4); ♂ 1.26–1.36, *m* 1.31 (4) Head, ♀ 0.30–0.31, *m* 0.304 (5); ♂ 0.28–0.30, *m* 0.29 (5). Abdomen, ♀ 0.93–0.99, *m* 0.96 (4); ♂, 0.67–0.77, *m* 0.705 (4). *Width* : Preocular, ♀ 0.33–0.34, *m* 0.335 (5); ♂, 0.31–0.32, *m* 0.315 (5). Temples, ♀, 0.46–0.47, *m* 0.467 (4); ♂, 0.41–0.43, *m* 0.42 (5). Pronotum, ♀, 0.31–0.32, *m* 0.312 (4); ♂, 0.27–0.29, *m* 0.28 (4). Metanotum, ♀, 0.48–0.50, *m* 0.485 (4); ♂, 0.28–0.40, *m* 0.395 (5). Broadest tergite, ♀, 0.65–0.68, *m* 0.67 (5); ♂ 0.49–0.50, *m* 0.495 (4). Length of post spiracular setae : ♀, III, 0.11–0.14, *m* 0.12 (7); IV, 0.37–0.42, *m* 0.40 (9); V, 0.11–0.16, *m* 0.13 (8); VI. 0.27–0.32, *m* 0.30 (8); VII 0.28–0.36, *m* 0.33 (9); VIII, 0.36–0.41, *m* 0.395 (9); ♂, III, 0.108–0.12, *m* 0.11 (8); IV, 0.36–0.40, *m* 0.39 (6); V, 0.12–0.14, *m* 0.13 (5); VI, 0.27–0.31, *m* 0.28 (6); VII, 0.25–0.31, *m* 0.28 (5); VIII, 0.36–0.40, *m* 0.39 (7).

Holotype : ♂ slide Reg. No. ERS/ZSI-AI/4440: INDIA : MEGHALAYA : Shillong (Risa colony), 18. viii. 1977 from *Garrulax phoeniceus bakeri* (Hartert), coll. R. K. Rai, **Paratypes :** 4 ♂♂ (one dissected) and 5 ♀♀ with data as given for holotype.

This species has been named in honour of Dr. T. N. Ananthakrishnan.

The key as provided by Tandan (1972) has been modified in relevant parts to accommodate the new species.

MALE

1. Hypopharynx fully developed.....2
—Hypopharynx reduced to varying degrees.....5

5(1). Pleurite II–VII without anterior setae (Text-fig. 2 *in* Tandan, 1972); the more central setae on tergum VIII may just cross posterior margin of tergum IX (Text fig. 19 *in* Tandan, 1972).....6 a

—Pleurite V always, II–IV and VI usually and VII occasionally with anterior setae (Text fig.28 *in* Tandan, 1972); two tergal setae on VIII extend well beyond posterior margin of tergum IX (Text-fig. 8 *in* Tandan, 1972).....9

6a(5). Tergum I with less than 8 setae.....6
—Tergum I with 12–13 (*m* 12.75) setae; genitalia and genital sclerite as in (Figs. 5 and 6).... .....*ananthakrishnani* sp. nov

6(6a). 6–7 (*m* 6.25) setae on tergum I; 8–9 (*m* 8.25) metanotal setae: genital sclerite as in (Fig. 53 *in* Tandan, 1972).....*singularis* Tandan

—4 setae on tergum I: 4–5 (*m* under 5) metanotal setae; genital sclerite not as above.....7

FEMALE

1. Hypopharynx fully developed.....2
—Hypopharynx reduced to varying degrees 5

5(1). Metanotum enlarged with 16–19 marginal setae; pleurite I with 9–11 long marginal setae forming a frill.....*singularis* Tandan

—Metanotum normal having under 11 marginal setae; less than 8 short and spiniform marginal setae on pleurite I 6

6(5). Pleurite II-VI without anterior setae; the more central setae on VIII not extending beyond posterior margin of tergum IX.....7

—Pleurite II or III–VI with anterior setae; 2 tergal setae on VIII extending well beyond posterior margin of tergum IX.....9

7(6). Terga I and II normal.....*sehri* Ansari

—Tergum I slightly or considerably enlarged, II normal or slightly modified.....8a

8a(7). Tergum I with less than 8 setae.....8

—Tergum I with 13–15, *m* 14. 20 setae, sternum IV narrowed medially ; VII–IX fused; Vulval margin strongly serrated.....
.....*ananthakrishnani* sp. nov

8(8a). The two central setae on tergum I long and markedly longer than the two lateral ones (Text fig. 1 *in* Tandan, 1972).....
.....*erythrocephali* Tandan

—The two central setae on tergum I short and fine and the two lateral ones slightly longer but considerably stouter (Text fig. 3 *in* Tandan, 1972).....*thailandensis* Tandan

Acknowledgements :—I am grateful to Dr. T.N. Ananthakrishnan, Director, Zoological Survey of India for his valuable guidance and permission to undertake the present work and to Dr. Asket Singh, Deputy Director, ERS/ZSI, Shillong for facilities. My sincere thanks are also due to Prof. B.K. Tandan and Dr. K.V. Lakshminarayana for several suggestions and useful comments.

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A NEW GALL-MIDGE (DIPTERA : CECIDOMYIIDAE) FROM INDIA

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(Received 27 April 1978)

This contribution reports the description of a new genus *Apamargamyia*, accommodating midges reared from the stem galls of *Achyranthus aspera* Linn. in the Marathwada University Campus, Aurangabad. The relative position of the genus along with others is also indicated in a key.

(*Key words :* **new gall-midge, *Apamargamyia orientalis***)

[1]Apamargamyia, gen. nov.

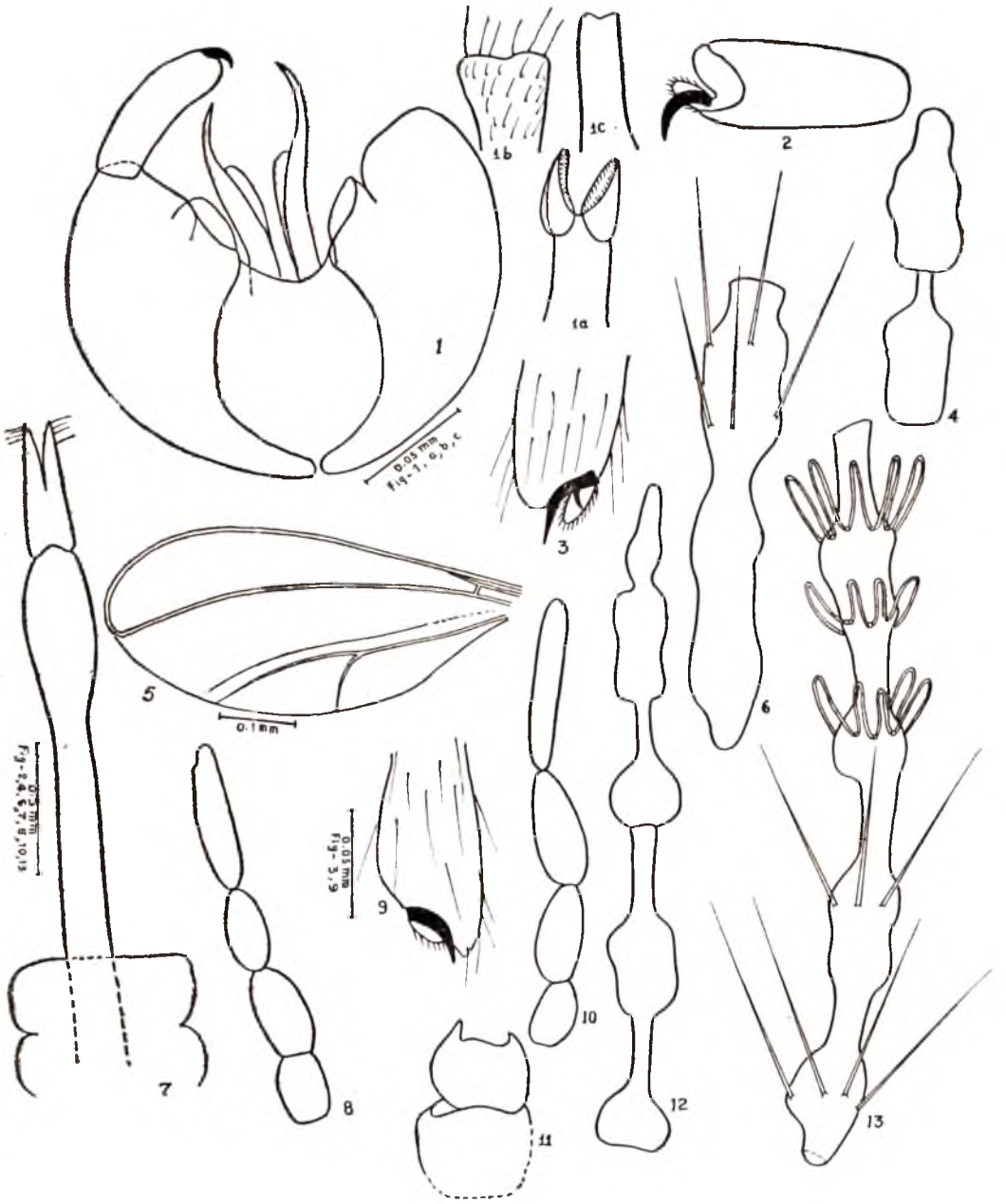
Eyes confluent above. Trophi normal. Palpi quadriarticulate. Antenna 2 + 12 segmented in both sexes; in male flagellate segments binodose with long stems, two whorls of long setae, one on each enlargements, three whorls of regular circumfila, one on basal and two on apical enlargements; in female flagellate segments cylindrical with short stems, two whorls of long setae, circumfila low, third and fourth antennal segments confluent; wings hairy, vein *Rs* present, vein *R*5 reaching wing margin well beyond its apex, vein M1 + 2 faint, vein *Cu* forked; claw dentate on front legs, simple on others in male; simple on all legs in female; empodium shorter than claw. Genitalia: basal clasp segment large, with a subapical blunt lobe; terminal clasp segment slender, ending in a strong pointed tooth; dorsal plate elongate, deeply bilobed; subdorsal plate broad entire, truncate apically; one pair of strong spine like curved interparameral squamae surrounding aedeagus, the latter long, tip notched in the middle. Ovipositor: exerted, protractile, lamellae lanceolate.

Type of the genus : *Apamargamyia orientalis;* gen. et. sp. nov.

Apramargamyia orientalis gen. et. sp. nov.

Male : Body 1.25 mm long. Palpus (Fig. 10) (figured from paratype) quadriarticulate, sparsely setose, first segment (10 : 6) short, cylindrical, length 1.66 × its maximum thickness; second segment (15 : 7) cylindrical, longer and broader than first, length 2.14× its maximum thickness; third segment (16:7) cylindrical, longer than second, length nearly 2.30 × its maximum thickness; fourth segment (24 : 4) cylindrical, longest and thinnest of all, length 6.00 × its maximum thickness. Antenna : longer than body with 2 + 12 segments, segments with binodose enlargements and long stems, becoming longer and thinner towards the tip of the antenna, with two whorls of long setae, one on each enlargement, three whorls of regular circumfila, one on basal and two on apical enlargements, middle whorl shortest; scape (Fig. 11) (15 : 18) broadest at apex than at base; pedicel (Fig. 11) (13 : 14) subglobose, wider than long; third segment (Fig. 13) (58) confluent with and longer than fourth, with a small basal prolongation (3 : 5), basal enlargement (14 : 11) 0.24 the length of the segment and 1.27 × its maximum

[1] Name associated with the Sanskrit name for *Achyranthus aspera* Linn. (Amaranthaceae) the host plant.



Apamargamyia orientalis; gen. et. sp. nov.

Figs. 1. Genitalia; a. dorsal plate; b. subdorsal plate; c. aedaegus; 2. front claw, female; 3. front claw, male; 4. terminal two antennal segments, female; 5. Wing, male; 6. third and fourth antennal segments, female; 7. ovipositor; 8. Palpus, female; 9. mid claw, male; 10. palpus, male; 11. scape and pedicel, male; 12. terminal two antennal segments, male; 13. third and fourth antennal segments, male;

thickness, basal stem (10 : 5) 0.71 the length of the basal enlargement and twice its maximum thickness, apical enlargement (19 : 11) 0.31 the length of the segment and 1.72 × its maximum thickness; apical stem (14 : 5) shorter than apical enlargement, length a little less than thrice its maximum thickness; fourth segment (Fig. 13) (53), basal enlargement (11 : 11) globose, 0.20 the length of the segment, basal stem (10 : 5) shorter than basal enlargement and twice its maximum thickness; apical enlargement (18 : 11) 0.34 the length of the segment, 1.80 × longer than basal enlargement and 1.63 × as long as thick, apical stem (13 : 5) shorter than apical enlargement and 2.60 × its maximum thickness; fifth to tenth segments (51) nearly similar to each other and shorter than fourth, eleventh and twelfth segments (50) similar and shorter than tenth; penultimate segment (Fig. 12) (48) shorter than twelfth, basal enlargement (7 : 10) 0.14 the length of the segment and broader than long, basal stem (11 : 3) longer than basal enlargement and less than 4.00 × its maximum thickness, apical enlargement (15 : 9) 0.30 the length of the segment, more than twice the basal enlargement and 1.66 × as long as thick, apical stem (14 : 3) 4.66 × as long as thick; terminal segment (Fig. 12) (51) longer than, penultimate, basal enlargement (9 : 9) globose 0.17 the length of the segment, basal stem (9 : 3) as long as basal enlargement and thrice its maximum thickness; apical enlargement (17 : 7) 0.33 the length of the segment, less than twice the basal enlargement and 2.42 × as long as thick, apical stem in the form of an apical knob (17 : 4) slightly shorter than apical enlargement and more than 4.00 × as long as thick. Wing: (Fig.5) (60 : 24), hairy, 2.50 × as long as broad, vein *R*1 meeting costa little before the basal 1/4 of the wing, vein *Rs* distinct, vein *R*5 reaching wing margin well beyond its apex and interrupting costa at its union, vein M1 + 2 present, faint; vein *Cu* forked. Legs : hairy, metatarsus (8) shorter than the terminal tarsal segment (14), second segment longest of all, shorter than the following segments combined together (56 : 69); claw (Figs. 3 & 9) dentate on front legs, simple on others; empodium shorter than claw (6 : 8). Genitalia: (Fig. 1, a, b, c,) sparsely setose, basal clasp segment (75 : 33) large, narrow at base than at apex with a subapical blunt lobe, length 2.27 × its maximum thickness; terminal clasp segment (30 : 11) short, slender, ending in a pointed tooth, 0.40 the length of the basal clasp segment, 2.72 × as long as thick; dorsal plate (60 : 20) elongate, bilobed, lobes tirangular, setose, densely hairy, length 3.00 × its maximum thickness; sub-dorsal plate (15 : 20) entire, truncate apically, apex fringed with setae, surface hairy, shorter than dorsal plate; parameres in the form of a pair of long curved spine like interparameral squamae, as long as basal clasp segment; aedeagus (45 : 20) cylindrical, broad at base than at apex, tip notched in the middle, length 2.25 × its maximum thickness.

Female : Body 1.40 mm long (including ovipositor). Palpus (Fig. 8) quadriarticulate; first segment (7 :5) short, length 1.40 × its maximum thickness ; second segment (15 : 8) cylindrical, length less than 2.00 × its maximum thickness; third segment (11 : 5) cylindrical, shorter than second, length 2.20 × its maximum thickness; fourth segment (20 : 4) cylindrical, longest and thinnest of all, length 5.00 × its maximum thickness. Antenna : half the length of the body with 2 + 12 segments, enlargements cylindrical with short apical stems, two whorls of long setae, circumfila low; scape and pedicel as in male; third segment (Fig. 6) (40) confluent with and longer than fourth, with a small basal prolongation (4 :4), enlargement (31 : 10) 0.70 the length of the segment and 3.10 × as long as thick, stem (5:5) 0.16 the length of the enlargement

and as long as thick; fourth segment (Fig. 6) (24), enlargement (20 : 10) 0.80 the length of the segment and 2.00 × as long as thick, stem (4 : 5) 0.20 the length of the enlargement and thicker than long; fifth, sixth and seventh segments (20) similar and shorter than fourth; eighth and ninth segments (22) similar and longer than seventh; eleventh and twelfth segments (21) similar, shorter than tenth; penultimate segment (Fig. 4) (21) as long as twelfth, enlargement (16 : 8) 0.76 the length of the segment and 2.00 × as long as thick, stem (5 : 2) 0.31 the length of the enlargement and 2.50 × as long as thick; terminal segment (Fig. 4) (21) as long as penultimate, stem in the form of an apical knob, longer than its own thickness. Wing : as in male; claw (Fig. 2) simple on all legs, evenly curved, empodium shorter than claw. Ovipositor (Fig. 7) exerted, protractile, lamellae lanceolate, setose.

Holotype : ♂ dissected and mounted on slide labelled as "Reared from stem galls on *Achyranthus aspera* Linn. along with lasiopterine midges, INDIA : MAHARASHTRA, Aurangabad, University campus, R. M. Sharma, Coll. 27. viii. 1977.

Allotype : ♀ dissected and mounted on slide data as in holotype reared on 3. ix. 1976. **Paratypes :** One ♂ and two ♀ ♀ on slides, data as in holotype for ♂ and as in allotype for ♀.

This new genus runs close to *Lobodiplosis* Felt (1908), but can be readily distinguished as shown in the key.

1. Claw dentate on fore legs in male.....2
——Claw dentate on all legs.....

2. Palpi 4-segmented.....3
——Palpi 3-segmented.....

3. Basal clasp segment lobed.....4
——Basal clasp segment not lobed.....

4. Lobe apical or subapical.....5
——Lobe sub-basal or basal.....

5. Basal clasp segment with ventroapical setose lobe; terminal clasp segment long and attenuate; aedeagus strongly recurved..... ..... *Lobodiplosis* Felt

——Basal segment with subapical asetose blunt lobe; terminal clasp segment short and slender; dorsal plate elongate, bilobed; subdorsal plate entire, truncate; interparameral squamae surrounding aedeagus; tip of aedeagus notched; ovipositor protractile, lamellae lanceolate..... *Apamargamyia* gen. nov.

The female is described from the material reared from the same host plant an year earlier than the material based on which the holotype male is described. The claws in both sexes are not similar. In male the front claws only are dentate, whereas the same in female are simple.

Acknowledgement:—We are thankful to the authorities of the Marathwada University, Aurangabad, for the award of a fellowship to the senior author.*

* Included in the Ph. D. thesis of this University of the senior author.

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TAXONOMIC NOTES ON A NEW SPECIES OF *GARGARA* AMYOT & SERVILLE (MEMBRACIDAE : HOMOPTERA) AND ITS IMMATURE STAGES

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(*Received 30 May 1978*)

Description of a new species of Membracidae, *Gargagra minuscula*, and its immature stages is presented.

(*Key words :* **Taxonomy, *Gargara miniscula* n. sp., immature stages)**

Gargara minuscula n.sp.

Female :

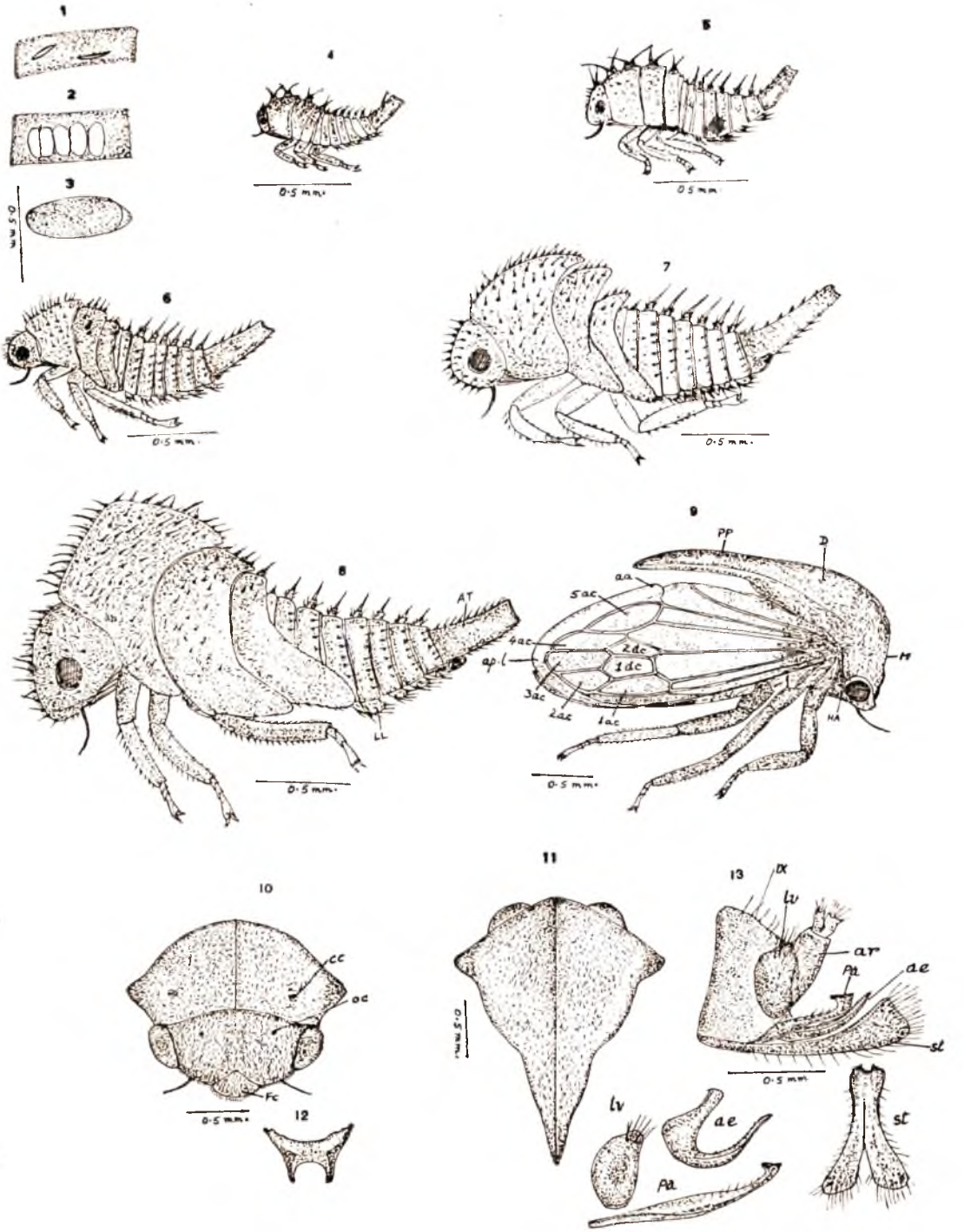
General colour grey or dark brown. Head vertical, nearly three times as wide as long, finely punctate, with golden pilosity ; vertex moderately convex, upper margin somewhat sinuous, lower margin obliquely passing to frontoclypeus ; eyes reddish brown, subglobate, ocelli black, closer to eyes than from each other and located above centro–ocular line; frontoclypeus as wide as one-third width of head, lateral lobes indistinguishably fused, apex broadly rounded and fringed with short silvery hairs ; rostrum extending upto hindcoxae. Pronotum reddish brown at the sides and light brown above, densely pilose ; metopidium dark brown, vertical upto one-third its height and then sloping backwards into disc, finely punctate and sprinkled with silvery hairs ; supra-ocular callosities prominent, black, overgrown by pilosity from surrounding areas ; humeral angles light brown: blunt ; posterior process about two-thirds as wide as long, emerging from the posterior margin of disc and contiguous with scutellum, and extending backwards beyond the anal angles of tegmina ; median carina percurrent continued through metopidium without any interruption on disc ; scutellum aborted centrally, its basal angles punctate and densely pilose. Tegmina nearly two and a third longer than wide, nearly hyaline except the basal fiifth which is dark brown, coriaceous and punctate ; veins yellowish brown, apical limbus broadest opposite to the 3rd apical cell ; 1st and 2nd discoidal cells of equal length, the latter not petiolate ; lateral areas of abdominal tergites punctate ; ovipositor dark brown. Legs with coxa and trochanter dark brown, the remaining segments light brown.

Measurements : Length from frontal margin to tips of tegmina 3 mm, to tip of posterior process 2.17 mm, width across humeral angles 1.9 mm, across eyes 1.48 mm.

Male :

General colour similar to female ; pilosity of body more dense than female ; genitalia as shown in figure.

Measurements : Length from frontal margin to tip of tegmina 2.8 mm, to tip of posterior process 2.0 mm, width across humeral angles 1.72 mm, across eyes 1.35 mm.



Gargara minuscula n. sp: 1. Egg slits on the host plant; 2. Egg slit cut open to show the arrangement of eggs; 3. Egg; 4. First instar nymph; 5. Second instar; 6. Third instar; 7. Fourth instar; 8. Fifth instar; 9. Adult female; 10. Frontal view of head and pronotum of female; 11. Dorsal view of the same; 12. Scutellum; 13. Male genitalia.

Immature stages :

First instar nymph: Length 0.65–0.75 mm. General coloration pale brown on upper surface, dull white ventrally ; body laterally compressed and appearing triangular in cross section through thorax ; head directed obliquely downward, more than two and a half times wider than long, tip of rostrum extending to the 5th abdominal segment ; cranial tubercles very short, each bearing a slender hair; vertex fringed with a few slender hairs directed forwards. Pronotum nearly as long as mesonotum and metanotum combined, with two pairs of tubercles each tipped with two hairs ; mesonotum bearing a pair of dorsal tubercles terminating in a pair of caudally turned hairs besides subspines ; first abdominal segment obscure 2nd, narrow, 3rd with a pair of caudally directed dorsal hairs not mounted on tubercles ; dorsal tubercles on segments 4-8 long, inclined backwards, each terminating in a long slender hair overlapping with the succeeding segement besides a subspine ; a pair of short dorsolateral tuberculate spines and lateral lamellae, the latter fringed with 2 backwardly turned spines ; anal tube as long as the four preceding segments combined, and one-fifth the total body length, bearing, a small dorsal and a large subterminal tuberculate spine.

Second instar nymph : Length 1.2 mm nearly twice as long as first instar ; prothorax slightly raised ; lateral margins of meso- and metatergites produced as small lobes ; abdominal dorsal tubercles more pronounced than those of the preceding stage ; pilosity scattered over the entire abdomen including anal tube ; lateral lamellae slightly larger ; anal tube one-sixth as long as the total length of body.

Third instar nymph : Length 1.5 mm. General colour much as in the preceding stage ; head and thorax densely pilose ; protergum produced backwars as a short process bearing a median carina with closely arranged short tuberculate spines ; wing pads appearing as short conical lobes fringed with spinules. Abdomen densely hairy, broadest at the level of the 3rd segment ; dorsal tubercles prominent, bearing slender tuberculate bristles arranged in a spiral fashion ; lateral lamellae of abdominal segments 5-8 fringed with 3 or 4 slender spines ; anal tube with dense hairs arranged in longitudinal rows, and about one-fourth the total body length.

Fourth instar nymph : General colour light brown ; length 2.1 mm ; body more hairy than in preceding stage ; head directed downwards ; metopidium slanting backwards to disc ; pronotal posterior process extending over basal half of mesonotum ; wing pads produced backwards as far as 3rd abdominal segment ; dorsal tubercles of abdomen longer than those of the preceding stage, bearing long slender tuberculate hairs throughout their length ; dorsolateral tubercles tipped with 2 or 3 spines ; lateral lamellae short, cylindrical, bearing 4 or 5 tuberculate spines ; genitallic rudiments clearly visible ; anal tube nearly one-fourth the total body length.

Fifth instar nymph : Body length 2.7 mm. General coloration dull yellowish

ABBREVIATIONS USED

1 ac - 5 ac–apical cells; ae–aedeagus; ap.l–apical limbus; ar–anal ring; AT–anal tube; CC–cranial callosity; D–disc; 1 dc–first discoidal cell; 2 dc–second discoidal cell; Fc–fronto-clypeus; HA–humeral angle; LL–lateral lamella; lv–lateral valve; M–metopidium; oc–ocellus; pa–paramere; pp–postereior process; st–sternal plate; IX–9th tergal plate.

brown sprinkled with black dots over tergites. Head turned backwards ; vertex two and a half times as wide as long, slightly convex at base, thickly pilose with tuberculate hairs ; lower margins of vertex broadly rounded ; frontoclypeus never extending beyond lower margins of vertex ; ocelli inconspicuous ; tip of rostrum extending beyond metathorax; metopidium convex and backwardly slopping to disc. Pronotal posterior process nearly half as long as pronotum, extending over the anterior half of mesonotum and ending in a subacute point ; wing pads buff, coriaceous, costal angles not distinct. Abdomen with dorsal tubercles well developed, each tubercle with a long spine and a cluster of subspines emerging from base ; dorsolateral tubercles less conspicuous than in the preceding stage ; lateral lamellae on abdominal segments 3-8 conspicuous, each provided with 5 or 6 tuberculate spines besides many short subspines ; anal tube about one fourth the total body length.

Host plant : *Moringa oleifera.*

Holotype : female ; **Allotype** male ; **Paratypes ;** 24 female and 2 male; 10 fifth instar **Nepionotypes** and numerous early nymphal instars, INDIA : TAMIL NADU, Madaras and Poonamallee, viii. 1977 to iii. 1978.

Gargara minuscula is closely related to G. *malabarica* Ananthasub.& Ananthak. (1975) in the general coloration of body, in the position of ocelli and in the nature of male genitalia, and to G. *madrasensis* Ananthasub., & Ananthak., (1975) in the nature of the metopidium and in the small size of body ; but it differs from both these species in he nature of the 1st and 2nd discoidal cells of tegmina which are of equal length, and in the nonpetiolate nature of the 2nd discoidal cell.

Acknowledgements :- Grateful thanks are due to Prof. T. N. Ananthakrishnan, Director, Zoological Survey of India, for constructive criticisms on the manuscript. Thanks are also due to the University Grants Commission, New Delhi, for the award of a Research Grant during the tenure of which this investigation was carried out.

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BRIEF COMMUICATIONS

SEXUAL MORPHS OF *CHROMAPHIS HERSUTUSTIBIS* KUMAR AND LAVIGNE (HOMOPTERA : APHIDIDAE) FROM INDIA

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Hitherto unknown alate male and apterous oviparous females of *Chromaphis hersutustibis* Kumar and Lavigne are described for the first time from Kumaon Himalaya, north west India.

(*Key words :* **Sexual morphs,** *Chromaphis hersutustibis*)

Kumar and Lavigne (1970) described *Chromaphis hersutustibis* from Simla, Himachal Pradesh, India. Subsequently, Quednau (1973) and Chakrabarti and Raychaudhuri (1978) reported this species from Nepal and India (Uttar Pradesh) respectively. However, hitherto unknown alate male and apterous oviparous females are described in this paper.

Alate male : Body 1.6 mm long. Head dark brown. Antennae 0.73 the body; processus terminalis about 0.44 the base of segment VI; segment III with 31, IV with 5–6, V with 3 and base of segment VI with 0–2 secondary rhinaria; longest hair on segment III about 0.75 the basal diameter of the segment. Thorax dark. Abdominal dorsum pale, with distinct paired brown marginal hair-bearing sclerites on tergites 1–5, but on 7th and 8th tergites these appear paler and smaller; spinal sclerites small and paired on tergites 1–3 but band-like on tergites 4 and 5; each of 7th and 8th tergite with a narrow band-like median sclerite; spinal hairs about 1.66–2.5 times and marginal hairs about 1.5–2.2 times the basal diameter of antennal segment III respectively. Cauda with 15 hairs. Opercula and penis distinct. Other characters as in alate viviparous females.

Measurements of the specimen in mm : Length of body 1.61, width 0.96; antenna 1.18; antennal segments III : IV : V : VI 0.50 : 0.24 : 0.23 : (0.09+0.04); ultimate rostral segment 0.078; second joint of hindtarsus 0.097; siphunculus 0.003; cauda 0.046.

Apterous oviparous female : Body pale, about 1.45–1.62 mm long. Frons with a pair of thick hairs with swollen apices arising from tuberculate bases, posterior to these another pair of similar hairs laterally arising from distinct tubercle. Antennae about 0.30–0.33 the body; processus terminalis 0.3–0.4 the base of segment VI; longest hair on segment III nearly 0.5 the basal diameter of the segment. Ultimate rostral segment about 0.60–0.64 the second joint of hindtarsus and bears 2 pairs of accessory hairs. Abdominal dorsum pale; hairs on anterior targites short and sparse, about 0.16 the basal diameter of antennal segment III; each of abdominal tergites 1–7 with paired round lateral tubercles bearing 2–3 hairs on each with spatulate apices, longest one about 1.5 times the basal diameter of antennal segment III. Hindtibiae somewhat swollen and bear 24–26 pseudosensoria. Other characters as in alate viviparous female.

Measurements of one specimen in mm : Length of body 1.45, width 0.70; antenna 0.42; antennal segments III : IV : V : VI 0.18 : 0.09 : 0.08 : (0.07+0.02); ultimate rostral segment 0.062; second joint of hind-tarsus 0.097; siphunculus 0.058.

Specimen examined : 2 apterous oviparous females, INDIA : UTTAR PRADESH Bhowali, 24. v. 1969 *Aleurites molucanu*; 1 alate male, Uttar Pradesh, Nainital, 23. v. 1969 from Yellow Pan Water Traps (coll. S. Chakrabarti); 2 apterous oviparous females, UTTAR PRADESH, Mussoorie, 24. vi. 1976 from *Juglans regia* (coll. S. P. Maity).

Acknowledgement :—The author expresses his thanks to the Head, Department of Zoology, University of Kalyani for laboratory facilities.

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MECHANISM OF SOUND PRODUCTION IN *HELIOCOPRIS BUCEPHALUS* FABR. (COLEOPTERA : SCARABAEIDAE)

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The hindcoxa of *Heliocopris bucephalus* Fabr. (Scarabaeidae) has a series of oblique striae on a small raised area and on the floor of the hind coxal cavity. When the striae of the hindcoxae are rubbed against the straie of the floor of the respecitve coxal cavities, the characteristic "wheezing" or grating sound is produced. The details of this sound producing mechanism are discussed.

(*Key words :* **sound production, *Heliocopris bucephalus***)

H. bucephalus belongs to the family of dung-rollers (Scarabaeidae) which are burrowing beetles. Some of the dung-rollers are reported to produce sounds by friction of two parts of the body (stridulation). According to LEFROY & HOWLETT (1909) the male *Bolboceras* has a corrugated expansion at the lower surface of the head and by moving its head up and down he rubs it against the edge of pronotum, producing a squeaking noise. The same authors state that in *Trox* the abdomen rubs against a raised vein in the elytra to produce sounds and in the case of *Heliocopris* the sound is produced by a rotation of the hindcoxa against the sharp edge of the coxal socket, producing a curious "wheezing" sound. DUMORTIER (1963) mentioned that in *Heliocopris* the mechanism of sound production is like that in *Geotrupes* where the coxa of the hindleg has an oblique line of striae on its upper face and when these striae scratch against the back edge of the coxal cavity, sound is produced. As the available descriptions of sound production in *Heliocopris* appeared to be vague and confusing, the present investigation was undertaken to study the actual mechanism involved in the production of sound in the case of male *H. bucephalus* living specimens of which are occasionally attracted to lights in Kerala during the rainy season.

For studying the external cuticular structures involved in the sound production, the adult beetles were dissected and observed under microscope. The cuticular structures of the coxa and coxal cavities were also treated with 10% KOH and the materials were then processed and mounted on slide for further microscopic examination. The diagrams were drawn with the help of camera lucida.

When the hindcoxa of male *H. bucephalus* is dissected out and examined under the microscope, a raised ridge (Fig. 2) on its inner broader end is observed. The raised ridge is found to have a small area having slightly oblique striae (Figs. 2 & 4). These striae are extremely fine and microscopic. Similar striae were observed on the floor (Figs. 1 & 3) of the hindcoxal cavity (Figs. 1 & 3) in the region of its posterior end. This area bearing the striae in the natural position is in contact with the coxal ridge bearing the striae. When the insect was turned upside down and held in the hand or placed on the floor, it was found moving both its hindlegs in the anterior-posterior axis. The hindcoxae

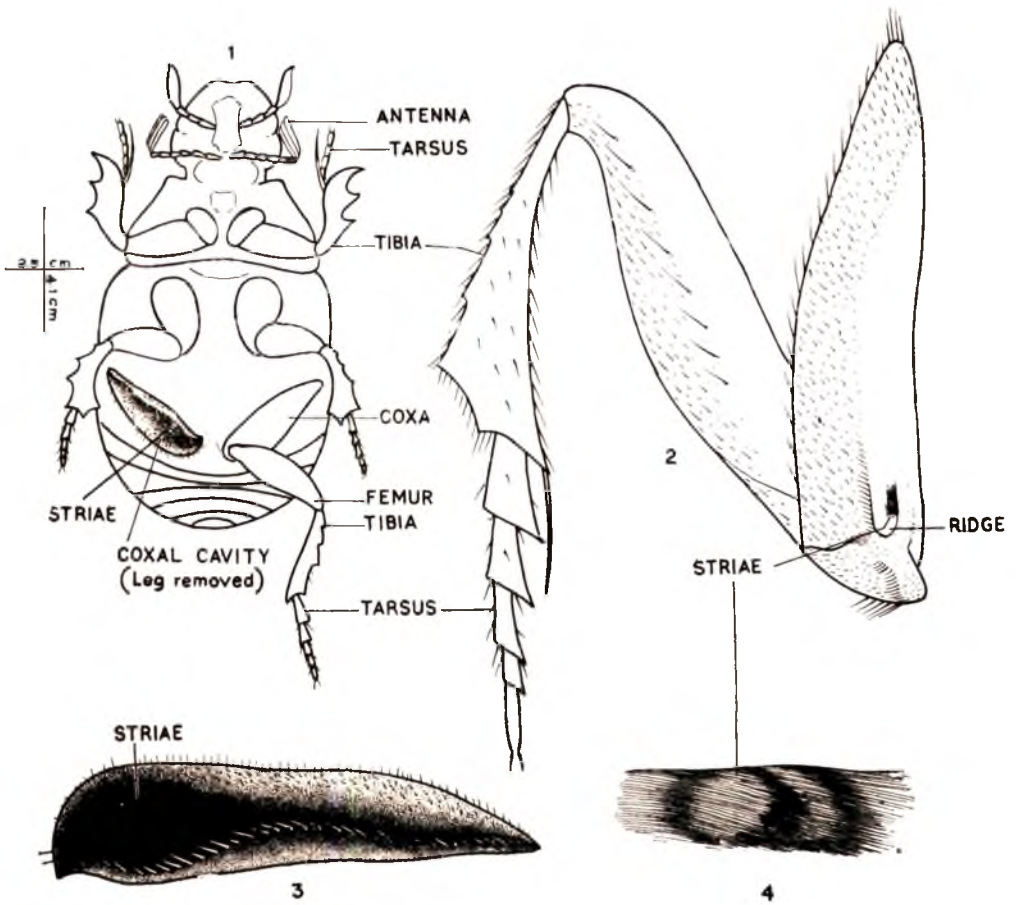

Fig. 1. *H. bucephalus* male, ventral view; Fig. 2. Hindleg of *H. bucephalus* male, showing the raised ridge; Fig. 3. Hind coxal cavity; Fig. 4. Striations of hindcoxa: enlarged view.

being fixed inside the coxal cavities along their anterior margin, their movements are limited to up and down motion of their hindmargin, comparable to the motion of the bellows of a hand operated harmonium. On closer examination it has been observed that during the up and down motion of the hindcoxae, their striae rubbed against the striae of their respective coxal cavities producing the "wheezing" or grating sound. It was possible to produce this sound even in the dead insect by moving the hindleg forwards and backwards causing the up and down motion of hindcoxa on its coxal cavity. To further confirm this sound production mechanism, the striae on one hindcoxa in a live beetle were smoothened out by using a minute needle without damaging the other parts and then when the beetle moved this particulr hindleg as before, no sound was produced. When the insect is held upside down in hand all the three pairs of legs are moved about but sound production is solely due to the movement of the hindlegs (and more exactly due to the movement of the hindcoxae in their coxal cavities. That the fore-and hindlegs are not involved in sound production is

proved by the fact that sound production is totally stopped when the movement of the hindlegs is alone prevented.

It is possible that the sound produced by the male *H. bucephalus* is a "distress call" since the insect produces it when it is held in the hand or otherwise restrained.

The mechanism of sound production, if any, in the female *H. bucephalus* could not be investigated for want of specimens of this sex.

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ALKALINE PHOSPHATASE ACTIVITY IN THE PUPAL STAGES OF *EARIAS VITELLA* FAB. (NOCTUIDAE : LEPIDOPTERA : INSECTA)

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The activity of enzyme, alkaline phosphatase during pupal development of *E. vitella* at controlled condition is presented. Alkaline phosphatase was most active on the first day of pupal period followed by a slight decrease from the second to the fourth day and thereafter a steep fall from fifth day onwards, minimum being on the last day of pupal development. Alkaline phosphatase was found to have some significant bearing on the body weight of the pupal instar.

(*Key words :* **alkaline phosphatase, pupa,** *Earias vitella*)

Functions of the acid and alkaline phosphatases in the embryonic and post-embryonic stages of insects have been studied by various workers (YAO, 1950; ITO, 1954; ROUSSEL, 1971; MULHERKAR *et al.*, 1972; YOO & KYUNG, 1973; NATH & BUTLER, 1973; PASTEUR & COSTAS, 1974). Alkaline phosphatase being the important metabolic enzyme is expected to undergo changes during pupal development. Keeping in view such an importance of this enzyme, the activity of alkaline phosphatase during pupal development of *Earias vitella* FAB., a cotton pest of India is undertaken.

For the quantitative analysis of alkaline phosphatase, the method described by KIND & KING (1954) was followed. The pupae of known weight representing different age groups were first washed several times with distilled water and dried with filter paper. These were then homogenised groupwise with 1 ml icecold distilled water and centrifuged in a freezing centrifuge. Supernatant was separated and used for the assay. Each experiment was repeated at least five times. The activity of phosphatase was expressed as mg of phenol liberated in 15 min/100mg of tissue at 37°C at pH 10.6.

Results are presented Table 1. The activity of alkaline phosphatase was at its peak on the first day of pupal development followed by a slight decrease which remained significantly unchanged from the second to the fourth day of pupal duration. From the fifth day pupae, the enzyme activity was found to drop steeply, the lowest shown on the eighth or the last day. A similar trend of changes in the activity of alkaline phosphatase was earlier reported by ROUSSEL (1971) in the pupae of *Musca autumnalis*, YOO & KYUNG (1973) in the pupae of pinemoth *Deudrolimus spectabilis* and by NATH & BUTLER (1973) in the pupae of the black carpet beetle, *Attagenus megatoma*.

The weight of the pupae was found to decrease with the growth of pupae (Table 1), maximum on the first day, when the enzyme activity was at its peak. It went down gradually with the growth, the minimum being obtained on the last day. From this observation it could be inferred that

TABLE 1. Changes in alkaline phosphatase activity during pupal development in *E. vitella.*

Age in days	1	2	3	4	5	6	7	8
*Unit	13	11	12	12	6	4	4	3
S D	4.0	3.66	3.73	3.48	0.89	0.65	0.63	0.59
Average wet weight of pupae (mg)	80	60	52	45	42	40	40	39

*Unit was expressed as the amount of phosphatase that liberated 1mg of phenol from phenyl phosphate in 15 min/100 mg of tissue at 37°C and pH 10.6.

with the advance of age, there occurred decreased cell proliferation causing reduction in weight. The association of alkaline phosphatase and its gradual decrease in activity with cell proliferation was earlier recorded by WILLMER (1942). According to BRADFIELD (1947) and DAVIDSON (1949), the phosphatases probably exert some role in the synthesis of protein. But main substrates utilised during pupal development, are fats, and a small amount of carbohydrates but not proteins. Moreover, the larval proteins are broken down to relatively complex peptides in the pupal instar. With relative drop in the protein level of the pupal instar there must be a drop in the activity of alkaline phosphatase. This could be the probable reason for the decrease in the enzyme activity.

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OVIPOSITION BEHAVIOUR OF *PERISIEROLA NEPHANTIDIS* MUESEBECK (BETHYLIDAE : HYMENOPTERA) A LARVAL PARASITE OF *NEPHANTIS SERINOPA* MEYRICK (XYLORICTIDAE : LEPIDOPTERA)

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(*Received 27 April 1977*)

Perisierola nephantidis **deposits eggs on the late instar caterpillars of** *Nephantis serinopa*. **It begins oviposition 4–5 days after emergence. The host larva is stung and paralysed before oviposition.**

(*Key words : Perisierola nephantidis*, *Nephantis serinopa*, **larval parasite, oviposition behaviour**)

A fascinating aspect of the relation that exists between the parasite, *Perisierola nephantidis* and its host, *Nephantis serinopa*, the black-headed caterpillar pest of coconut, is revealed by the study of the oviposition behaviour of the parasite. Brief accounts of the life history and certain other aspects of the biology of this parasite have been given by RAMACHANDRA RAO & CHERIAN (1928), JAYARATNAM (1941), DHARMARAJU (1952), ANTONY & KURIAN (1960), SESHAGIRI RAO *et al.* (1967) and DHARMARAJU & PRADHAN (1976). In the present paper, the pre-ovipositional requisites, the stages of oviposition, arrangement of eggs on the host larva, peak hours of egg-laying, effect of temperature on oviposition, etc. are very birefly discussed.

P. nephantidis were reared in glass tubes (2.5 cm × 10 cm) closed by coton plugs. The larvae of *N. serinopa* or *Corcyra cephalonica* were provided into the tubes. They were also reared in large glass jars covered by muslin cloth and provided with infested coconut leaves.

The egg-laying potential is attained by the wasp 4–5 days after emergence. Mating is not an essential pre-requisite for oviposition. The females enter the galleries of 4th or 5th instar caterpillars and also the pre-pupal cocoons of *N. serinopa* by cutting their way in with the help of the mandibles. Using the mandibles, the parasites cling on to the caterpillars and sting the ventral side of the head. The host

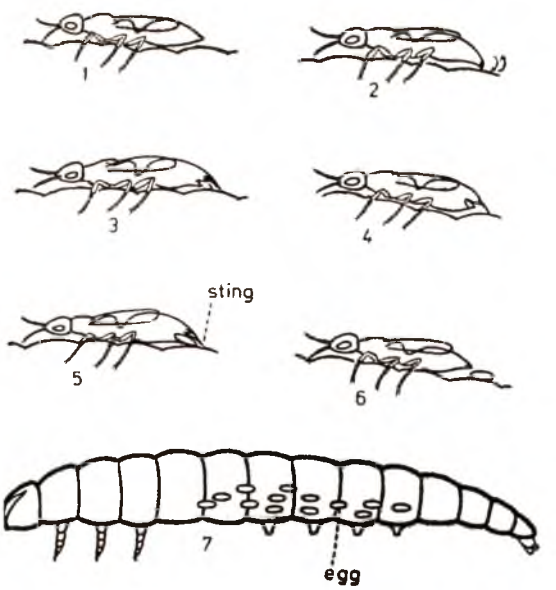

Fig. 1–6. Stages of oviposition; Fig. 7. Arrangement of eggs on the host body.

larva tries to avoid the parasite by wriggling but the tight grip by the parasite prevents its dislodging. The larva gets paralysed soon or within one hour. The parasite may oviposit soon, or may be prolonged to one day or more in certain cases. The larvae which already bear the eggs are usually avoided by the ovipositing females and they refrain from ovipositing until a new larva is provided.

P. nephantidis conducts a thorough checking of the host larva by walking on the body surface and feeling the surface with its antennae. If found suitable, it rests on the surface of the host, which in some cases lasts for many hours. Just before laying the egg, the particular spot is searched out with the help of the gonostyli (Figs. 1 & 2). The sting is then protruded out (Fig. 3). The tip of the sting is pressed on the surface of the host larva, and this helps to maintain a grip on the host larva during the violent muscular contractions that accompany oviposition. Vulva is opened and the egg comes out through the opening of the oviduct, situated at the base of the sting (Figs. 4, 5 & 6). The antennae and wings remain motionless. The final stage of egg explusion in some instances is marked by the forceful up and down movements of the hindlegs. The pointed end representing the posterior pole of the egg comes out first. The sting is withdrawn soon after oviposition.

The female takes 1.5–2 minutes for laying a single egg. The interval between two successive egg depositions varies from 1–15 minutes. The duration between the laying of 2 sets of eggs varies from 1–3 days. At a stretch about 8–12 eggs are laid by a female. Fecundity of the parasite is increased by feeding it with honey or sugar solution. The eggs are usually arranged horizontally parallel to the long axis, on the lateral sides of the abdominal segments. (Fig. 7). The eggs are glued well to the surface. Occasionally two females oviposit at the same time on a single larva. The eggs are usually taken care of by the female; but very rarely they are eaten up by her.

Oviposition usually takes place in the afternoon hours from 12 noon to 7 p.m. The maximum number of eggs are deposited between 4 pm and 6 pm as given in the graph (Fig. 8). Hence it is reasonable

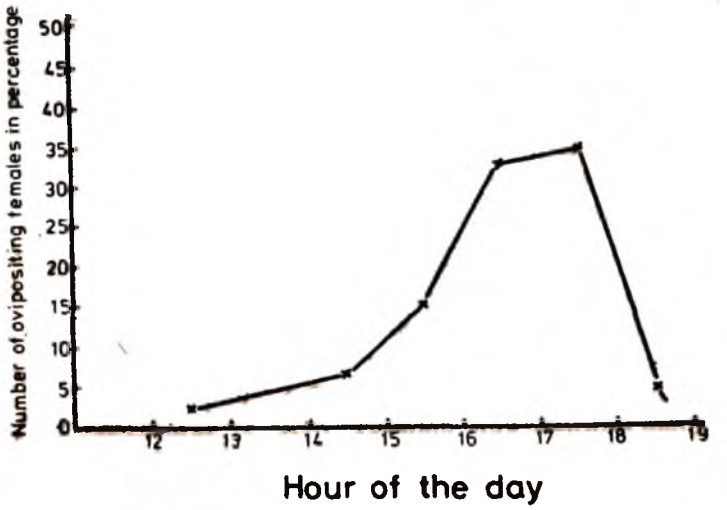

Fig. 8. Graph showing the peak hours of ovposition

to believe that there is some endogenous biological rhythm influencing the oviposition behaviour.

To test the effect of temperature, the tubes containing *P. nephantidis* and the host larvae were kept at different temperatures, viz., 14°C, 24.5°C, 34°C and 37°C. At 14°C and 37°C oviposition did not occur. At 24.5°C the number of eggs laid were few, when compared with the eggs laid at normal laboratory temperature (29–33°C). At 34°C, oviposition was very much reduced.

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STUDIES ON THE EFFECT OF TEMPERATURE ON THE DEVELOPMENT OF *CAMPOLETIS CHLORIDEAE* UCHIDA (ICHNEUMONIDAE), AN INTERNAL LARVAL PARASITE OF *HELIOTHIS ARMIGERA* (HUBN.)

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The paper deals with the effect of temperature on the development of and longevity of adults of *C. chloridеae* UCHIDA collected on Sorghum. The observations were made at room temperature and at constant temperatures. The optimum temperature for development was found to be 31 ± 1°C.

Heliothis armigera (HUBN.), the gram pod borer is cosmopolitan, widely distributed through Africa, Asia and Europe. It is an important polyphagous, agricultural pest which causes very serious loss to a wide variety of crops of economic importance. In India *Heliothis armigera* is recorded on cereals, fiber crops, oil seeds, pulses, vegetables, etc. *Campoletis chlorideae* is an internal larval parasite of *H. armigera*. The observations deal with the effect of temperature on the development of *C. chlorideae*. These studies were carried out at the room temperature (28°C) and also at constant temperatures viz. 31°C, 33°C, 36°C and 38°C.

Breeding of *Campoletis chlorideae* was started using parastized first instar larvae of *Heliothis armigera* collected from Agricultural School farm, Aurangabad, Maharashtra State in September—October 1976. Larvae of *H. armigera* were exposed (2 to 3 days old) in breeding cages to newly emerged mated females of *C. chlorideae*. Parasitized larvae were transferred to small separate containers. The effect of temperature on the development of *C. chlorideae* from egg to emergence of the adult and the longevity of adult was studied with rearing procedure at the constant temperatures maintained in the oven. The observations were made at instervals of six hours. The time of parasitization in host larvae to emergence of last instar larva gives the egg—larval period and from formation of cocoon by parasitoid prepupa to emergence of adult gives pupal period. The longevity of adults was studied by caging into 2.5 cm × 15 cm test tubes with 20% honey solution as food. During experimental work the room temperature noted was 28 ± 1°C and the constant temperatures were 31 ± 1°C, 33 ± 1°C, 36 ± 1°C and 38 ± 1°C.

The results are shown in Table 1. The egg—larval development is completed in 186 hr, 178 hr, 164 hr, 144 hr and 130 hr at 28°C, 31°C, 33°C, 36°C, and 38°C, respectively; percentage survival of lrvae is 72%, 80%, 60%, 52% and 40% respectively. The survival percentage of larvae is the highest at 31°C.

The pupal development at 28°C, 31°C, 33°C, 36°C, and 38°C completed in 236 hr, 224 hr, 216 hr, 198 hr and 186 hr and the percentage of survivial of pupae is 68%, 88%, 62% and 50% and 40% res-

TABLE 1. Effect of temperature on the egg—larval, pupal development and longevity of adult.

Temperature	% of survival of parasitic larvae	% of pupal surrival	Av. larval period	Av. pupal period	Av. longivity of adult
1	2	3	4	5	6
28 ± 1°C	72	68	7 days, 18 hr (186 hr)	9 days, 20 hr (236 hr)	8 days
31 ± 1°C	80	88	7 days, 10 hr (178 hr)	9 days, 8 hr (224 hr)	9 days
33 ± 1°C	60	62	6 days, 20 hr (164 hr)	9 days (216 hr)	7 days
36 ± 1°C	52	50	6 days (144 hr)	8 days, 6 hr (198 hr)	6 days
38 ± 1°C	40	40	5 days, 10 hr (130 hr)	7 days, 18 hr (186 hr)	4 days

NOTE :- 50 parasitoid larvae, fifty cocoons and 25 adults, were taken for the egg-larval, pupal development, and longevity of adults respectively.

pectively. Here also highest percentage of survival is at 31°C,.

The longevity of adults is also observed at the same constant temperature by providing 20% honey. The average longevity and the percentage of survival is high at 31°C. The longevity observed is 9 days at this temperature with 80% survival and it decreases to 4 days and 32% at 38°C.

The development from oviposition to emergence of adult is completed in 422 hr, 402 hr, 380 hr 342 hr and 316 hr at 28°C, 31°C, 33°C, 36°C and 38°C, respectively.

The effect of temperature on the development of *Campoletis chlorideae* UCHIDA, is studied here for the first time. BELING (1932) studied the effect of temperature on the development of *Diadegma* sp. (= *Angitia armillatae* GRAV.), a parasite of *Endrosis sareitrella* and FISHER (1959) on *Casinaria* sp. (= *Horogenes chrysostictus* GMELIN) and *Nemeritis cenescens* GRAV., the parasites of *Ephestia cautella* and *E. sarcitrella* respectively. In these parasites development cannot be completed above 33°C. Average larval and pupal period decreases from 49 days to 20 days and 102 days to 21 days respectively at 15°C, 30°C and in *C. chlorideae* these periods decreases from 17 days and 14 hours to 13 days 14 hours at 28°C to 38°C. The optimum temperature for *C. chlorideae* is 31°C while in others 18°C to 20°C.

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PROTEINS IN THF HAEMOLYMPH AND MALPIGHIAN TUBULES OF *LACCOTREPHES MACULATUS* FABR, (HETEROPTERA, NEPIDAE) IN RELATION TO FEEDING AND STARVATION

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(*Received 16 January 1978*)

Total protein content in the haemolymph and the malpighian tubules of both regularly fed and starved *Laccotrephes maculatus* was determined. In the case of regularly fed insects the total protein of both these tissues is more or less constant whereas in starved ones it falls gradually.

(*Key words :* **Proteins, haemolymph, malpighian tubules,** *Lacotrephes maculatus*,)

ORR (1964a) has reported a striking rise in the blood proteins on the third day after feeding in *Phormia regina*. A substantial increase in the haemolymph proteins is found after one day of feeding in the house fly (BODNARYK & MORRISON, 1966). Starvation has also been demonstrated to bring in a reduction in the total protein (BEADLE & SHAW, 1950; ORR, 1964b; WIGGLESWORTH, 1972). In the present study the total protein content both in the Malpighian tubles and the haemolymph is estimated in *Laccotrephes maculatus* in relation to feeding and starvation.

Freshly collected *L. maculatus* were reared in laboratory. Male insects of more or less the same weight were removed from the rearing troughs and starved for 6 days in separate jars, each containing 6 insects, with water. Then they were fed with mosquito larvae, at regular intervals for 4 days after which they were separated into two groups. One group was maintained without food; the other serving as control was fed regularly with mosquito larvae. The insects of the two groups were sacrificed at regular intervals for analysis of protein in haemolymph and malpighian tubules. The haemolymph and the malpighian tubules were collected as described previously (MOHAMED, 1976).

Protein was estimated by Lowry's modification of Folin's method (Lowry *et. al.*, 1951). Bovine serum albumin was used as the standrad.

Total protein content in the haemolymph and the malpighian tubules of normally fed *L. maculatus* ranges from 0.124 ± 0.006 mg to 0.138 – 0.009mg/100mg in tubule tissue and 12.4 ± 3.81 to 13.0 ± 6.2 mg/100ml in the blood.

During the starvation total protein content of the malpighian tubules as well as the haemolymph falls gradually to extreme low levels (Table 1). Since the insects die or become inactive at the end of 9th day of starvation no estimations could be possible beyond this period. It is demonstrated that

TABLE 1. Proteins in male *L. maculatus*.

	Malpighian tubules, mg/ 100 mg		Haemolymph, mg/100 ml	
	Fed	Starved	Fed	Starved
0 hour	0.13±0.004	0.13±00.01	12.8±2.32	13.1±00.2
12 hours	0.130±.004	0.13±0.004	12.6±0.81	12.6±2.8
24 hours	0.133±0.02	0.11±0.008	12.8±0.8	12.6±2.8
48 hours	0.1360±.001	0.09±0.004	13.0±6.2	12.8±0.4
72 hours	0.135±0.006	0.06±0.0003	12.9±0.8	8.4±2.9
96 hours	0.1260±.004	0.04±00.08	12.4±3.81	3.4±0.6
120 hours	0.1380±.009	0.02±0.001	12.8±2.6	4.2±0.2
144 hours	0.13±0.004	0.02±0.0006	12.6±1.2	2.6±0.5
192 hours	0.13±0.002	0.01±0.008	12.4±4.2	3.0±0.06
240 hours	0.124∓0.006	0.008±0.0001	12.6±1.8	2.1±0.12

protein content of insects drops to extreme low levels during enforced starvation (HELLER, 1926; BEADLE & SHAW, 1950; ORR, 1964b; WIGGLESWORTH, 1972). It is evident from this study that the unfed insects utilise both blood and tissue proteins during starvation.

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ON THE OCCURRENCE OF *ASSUANIA* SP. (CHLOROPIDAE : DIPTERA) AS A PEST OF BANANA

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(*Received 3 August 1978*)

***Assuania* sp. (Chloropidae : Diptera) has been recorded as a new pest of banana (*Musa* sp.) in Kerala.**

(*Key words : Assuania* **sp., new pest on banana**)

Maggots of *Assuania* sp. (Chloropidae : Diptera) were recorded infesting the banana variety 'nendran', in parts of Trichur District, during June–August 1977. The maggots congregate in groups of 30–50 on the exposed basal areas of the central spindle of unopened leaf around margins and mine into the tissues in between the epidermal layers. As a result of feeding, the infested regions of the spindle become slimy and these get stuck to the rest of the spindle. The infested spindles do not open completely (Fig. 1) and further normal growth of plants is arrested. The percentage infestation of the spindles ranged from 20% to 50%. The infestation was brought under control by high volume spot application of quinalphos (0.08%) or fenthion (0.05%) suspensions. The greyish-black and agile adults, when confined in glass jars containing excised bits of central leaf whorl, laid off-white, spindle shaped eggs, in groups of 6–10, on exposed portions. At 27 ± 0.5°C and 75% RH, the eggs hatched out after 6 days. The maggots on hatching mined into the leaf and fed on the internal contents. The larval and pupal periods lasted for 10 and 5–7 days respectively.

Assuania Becker 1903, is a genus which is hitherto known to be represented by a single species in the Oriental region (CHERIAN 1977, Personal communication) and this has so far not been recorded as crop pests.

Fig. 1. Central spindle of banna infested by *Assuania* Sp.

Acknowledgement :—The authors are grateful to Dr. P.T. Cherian, Zoologist, Zoological Survey of India, Calcutta–12 for identification of the insect.

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NEW RECORD OF *TETRALEURODES SEMILUNARIS* CORBETT (ALEYRODIDAE : HEMIPTERA) AS A PEST OF LEMON GRASS *CYMBOPOGON FLEXUOSUS* (STEUD.)

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(Received 9 August 1978)

Tetraleurodes semilunaris CORBETT (**Aleyrodidae : Hemiptera**) **has been recorded as a new pest of lemon grass** *Cymbopogon flexuosus* **(Steud.) in Kerala, India.**

(*Key words : Tetraleurodes semilunaris*, **new pest, lemon grass**)

The sedentary nymphs of *Tetraleurodes semilunaris* CORBETT were observed infesting leaves of lemon grass, *Cymbopogon flexuosus* (STEUDL.) in the Central State Farm, Aralam, Cannanore district, Kerala, India during February, 1978. This is the first time the insect is recorded in India and as a pest of lemon grass. *T. semilunaris* has been recorded in Ceylon as a pest of citronella grass, *Cymbopogon nardus* L. (CORBETT, 1926). The only other record of the genus *Tetraleurodes* in India is of *T. citriculus* DOZIER infesting citrus in the Punjab (CHOPRA, 1928).

Numerous scale like sedentary nymphs were seen all over the upper leaf surfaces (Fig. 1). The mean population per cm²

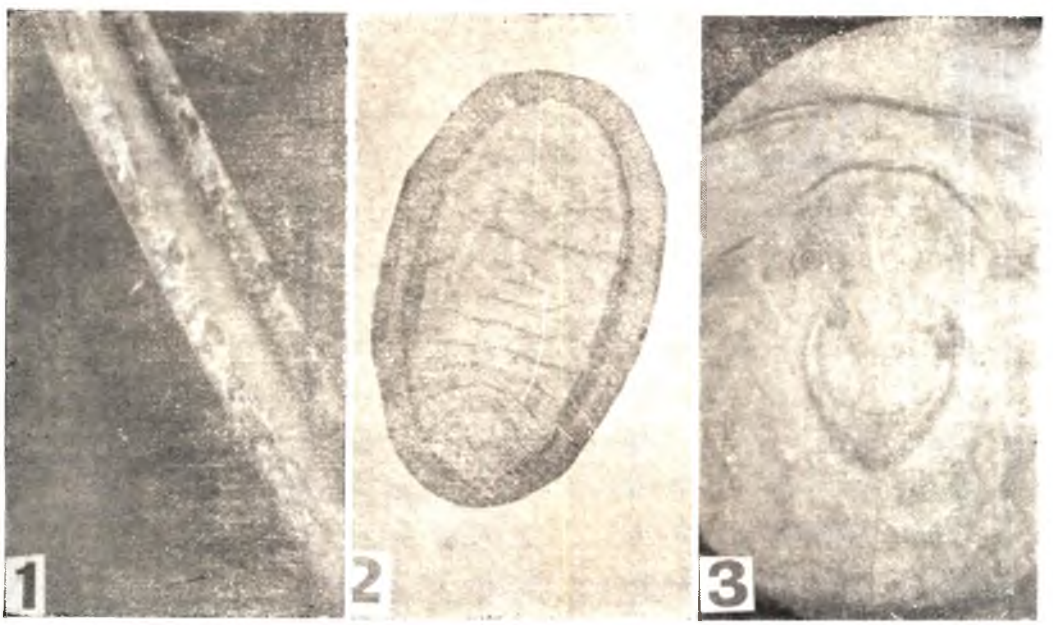

Fig. 1. *T. semilunaris* on lemon grass leaf; Fig. 2. Fully grown nymph of *T. semilunaris*; Fig. 3. vasiform orifice showing operculum and exposed lingula.

of the laminar area being 6.26 (n=164 over 26.19 cm^2). Infested leaves become chlorotic due to drainage of sap and eventually started withering up. There was copious exudation of honey dew and the development of sooty mould fungus.

The full-grown nymphs are dark brown, elliptical (Fig. 2) with powdery fringe around the margins. Their mean length and breadth are 1.530 mm and 0.979 mm respectively. Close to the distinct suture that demarcates the sub-marginal area, about sixty pairs of semilunate pores are present at equidistant intervals. The vasiform orifice is sub-cordate (Fig. 3) and the operculum fills about 2/3 of the orifice exposing the tip of lingula.

The pest infestation could be controlled very effectively by high volume application of 0.05% dimethoate (rogor) emulsion.

Acknowledgement : The authors are thankful to Dr. M.G. Rama Das Menon, Emeritus Scientist, Kerala Agricultural University, for the identification of the insect. They are also grateful to the Agricultural Officer, Central State Farm, Aralam and to Sri. E.V.G. Nair Associate Professor, Lemon grass Research Station, Odakkali, for the help rendered in the field collection of the pest.

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A NEW LEAF MINER OF BRINJAL

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Life history and damage by *Megalocypha* sp. nr. *microcasis* MEYRICK (Gelechidae) a new leaf miner of brinjal are given.

(*Key words :* **Brinjal, a new leaf miner)**

Brinjal (*Solanum melongena*) was seen during late 1977 badly infested by the leaf mining caterpillar of *Megolocypha* sp. nr. *microcasis* MEYRICK (Gelechidee) in some vegetable gardens of Trivandrum District. This is the first record of this insect in India as a pest of brinjal. Results of observations made on the biology of the insect in the laboratory are presented in this paper.

Brinjal seedlings were planted in paper cups and enclosed in glass chimneys closed with muslin cloth. Adult male and female moths were released on the caged seedlings for egg laying. The eggs laid were counted each day. The egg, larval and pupal instars were observed on these seedlings. These observations were made during August to November 1977.

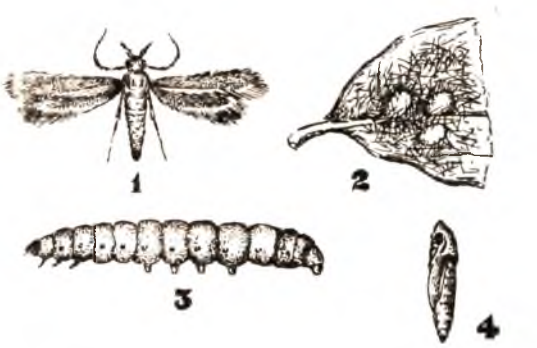
Life history

Adult emerges at night and mating takes place in the following night. Oviposition commences from the 3rd day of emergence and continues for 2 days. Eggs are laid on undersurface of leaves among the cuticular hairs of the leaf surface (Fig. 2). The number of eggs laid varies from 11 to 15 per moth.

The egg is oval in shape cream white when freshly laid, turning yellowish during the course of development. Hatching takes place in 8–9 days, the percentage of hatching being 92–97%.

The first instar caterpillar remains on the leaf surface for one day and starts mining from the 2nd day onwards on the under-surface of the leaf. There are five larval instars. First instar lasts for 2 days. It is 2·7 mm long with a head width of 0.22 mm. The 2nd, 3rd, 4th and 5th instars (Fig. 3) measure 3.8, 4.0, 4.4 and 6.0 mm in length and 0.24, 0.4, 0.76 and 0.92 mm in head width respectively; the duration of each instar is 2 days.

The total larval perod extends for about 10 days. The full grown larva comes out of the larval mine and pupates (Fig.5) under a silken web on the underside of the leaf for 6 days.



Figs. 1–4. Life stages of *Megalocypha* sp. nr. *microcasis:* 1. Adult moth; 2. egg; 3. Caterpillar; 4. Pupa.

Fig. 5. Leaf with pupa inside the pupal web.

Fig. 6. Leaf showing larval mines.

Adult (Fig. 1) measures 1.1 cm in wing span and 0.6 cm in body length. Longevity of the adult is 6–7 days.

The total life cycle from egg to adult takes 24–25 days for completion.

Damage caused

The caterpillars mine the upper surface of leaves causing white dry ptches. A leaf may show 10–15 larval mines (Fig.6). The leaves thus infested turn yellowish subsequently and dry up completely.

Acknowledgements:-Thanks are due to Dr. N.C. PANT, Director, Commonwealth Institute of Entomology, London for kindly arranging the identification of the insect.

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BOOK REVIEW

FORAGE AND PASTURE INSECT PESTS OF RAJASTAN, by K. S. KUSHWAHA AND S. C. BHARDWAJ, Indian Council of Agricultural Research, New Delhi, 1977, 186 pp. Rs. 21.75

In this book is presented results of the studies made under the ICAR project 'Investigations on Forage and Pasture Insects of Rajastan (1961–66)' at the University of Udaipur. This appears to be the first ever attempt made to study the pest problems of fodder crops and pasture objectively in India. The present publication which embodies the results of these studies is thus the first of its kind. Going through the report one is struck with the enormity of the problem of insect infestations on forage crops and pasture. Thus 54 species of insects are recorded on lucerne, 20 on maize, 18 on berseem, 17 on cowpea, 12 on pearl millet, 11 on sorghum, 10 on Johnson grass, 9 on oats, 7 each on soybean and gram, 5 on cluster bean and 2 on fenugreek. Pasture herbage has in association with them 51 species of insects of which 31 species are grasshoppers.

Biology and control of the more common species and the seasonal life history and population of quite a large number of the species are presented. Host–biology relations of some important pests have been indicated. Information gathered on the question of persistence of residues of malathion on lucerne and in milk of cows is also represented.

The book is profusely illustrated and they together with the tabulated biometric data aid in identifying the insect species. There is also an exhaustive list of references of the relevant literature on the subject. The book is a valuable contribution which will be useful to students and teachers of agricultural entomology as well as to extension specialists.

M. R. G. K. NAIR

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